경제학박사 학위논문

# Global Value Chains (GVCs), Upgrading and Economic Growth

## 글로벌 가치사슬 (GVCs), 업그레이딩 그리고 경제성장

2019년 8월

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경제학부 경제학 전공

MAO ZHUQING

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지도 교수 이근

이 논문을 경제학박사 학위논문으로 제출함

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MAO ZHUQING


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부위원장 이 근 (인)

위 원 Swati Mehta (인)

위 원 정 무 섭 (인)

위 원 이 현 태 (인)

# Abstract

# Global Value Chains (GVCs), Upgrading and Economic Growth

Zhuqing Mao

Department of Economics

The Graduate School

Seoul National University

Global Value Chains (GVCs) have been identified as an important determinant of economic growth with the rise of intermediate trade. Information and communication technology (ICT) revolution has brought in a new wave of globalization. In this new wave, latecomers obtain the opportunities to integrate into the global production network. Additionally, the international separation of production process has resulted in shifting many production stages to the latecomers (Baldwin, 2016) who have been trying to improve their positions in the global economy. This progress is called GVC upgrading (Gereffi, 2015).

Humphrey and Schmitz (2002) present the following four types of upgrading: process, product, functional, and intersectoral upgrading. Pietrobelli and Rabellotti (2011) indicate that process or product upgrading is a regular phenomenon, while functional upgrading occurs rarely. Lee and Mathews (2012) emphasize that functional and intersectoral upgrading are the keys to a successful catch-up model. In other words, GVCs may not automatically facilitate functional upgrading and latecomers might be stuck at low-value-added activities or segments; this depicts the

case of the middle-income trap (Humphrey and Schmitz, 2004; Lee et al., 2018; Blažek, 2015).

Previous studies mostly focus on the linear relationship between GVCs and economic growth (UNCTAD, 2013; WTO, 2019; Fagerberg et al., 2018) or the positive and linear relationship between GVCs and productivity (Formai and Caffarelli, 2015; Kordalska et al., 2016; Neagu et al., 2017). Recently, the non-linear GVC participation pattern has been confirmed at the national level in Lee et al. (2018) who proposed an N-shaped pattern of GVC participation in successful catch-up economies by looking into firm cases of upgrading in Korea and Brazil and the GVC data. The N-shaped pattern indicates that more GVCs are helpful for learning from the outside at the initial stage of growth, less foreign-dominated GVCs are required for functional upgrading at the middle stage of growth, and more GVCs effectively seek benefits at a higher stage of development after building up their own local value chain.

The purpose of this research is to investigate whether and how the non-linear GVC participation pattern works for economic growth at the national level and for productivity upgrading at the sectoral level. Subsequently, the study aims to find out differences between sectoral GVCs in different sectoral innovation systems.

First, this study utilizes a national database (Penn Word Table) and trade database (TiVA) to confirm the actual effects of GVCs on economic growth in only upper middle- and high-income economies. Hence, I focus on a U-shape (not the whole N-shaped pattern) hypothesis between the share of foreign value added in gross exports and economic growth. The U-shaped hypothesis is verified by using not only pooled OLS but also fixed-effect, system generalized method of moments (GMM), and three stages least squares (3SLS) estimations.

Second, in order to investigate the non-linear GVC participation for labor productivity at the sectoral level, this study utilizes two big industry databases (WIOD and UNIDO) that are matched respectively with the trade database (TiVA), and conducts analysis of nine manufacturing sectors. The empirical analysis in this study uses the sectoral data of upper middle- and high-income economies only and

thus focuses on the U-shaped (not the whole N-shaped pattern) hypothesis between the shares of foreign value added in gross exports and labor productivity through pooled OLS, fixed-effects, and system GMM estimations. The U-shaped hypothesis is confirmed for most of the sectors with some sectoral variations.

Third, in order to find out differences in different innovation systems, this research uses the matched data from an industry database (WIOD) and trade database (TiVA). Manufacturing sectors are separated into the explicit knowledge-based sector and the tacit knowledge-based sector. The fixed-effect and system GMM estimation results demonstrate the relatively high openness and low marginal effect of the explicit knowledge-based sector.

The study suggests that increasing GVC participation for economic growth and sectoral upgrading should be implemented with caution, and the key is to be able to increase domestic value-added at some point in the development process. Particularly, industry policymakers should consider the characteristics of each sectoral GVC.

**Keywords: GVC, Upgrading, Economic Growth, Non-linear Relationship, Labor Productivity, Sectoral Innovation System**

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# Chapter 1. Introduction

## 1.1. Motivation and Objectives

The Information and Communication Technology (ICT) revolution has led to the new globalization, characterizing international separation of production activities and a shift in several stages of production to latecomers (Baldwin, 2016). The different production stages located in different countries are called Global Value Chains (GVCs). The Global Production Network (GPN) and Global Commodity Chain (GCC) are similar concepts associated with the GVC. The key words associated with GVCs are production segments (fragments), and production tasks; these keywords imply that it is not necessary for firms intending to integrate into GVCs to hold whole value chain; these GVCs have increased with a surge in the intermediate goods trade in the world. This surge offers opportunities to latecomers. Therefore, GVCs have been identified as an important determinant of economic growth in development studies.

The rise in GVCs arousing scholars' interests to investigate on gains from GVCs and to connect GVC with growth. A study UNCTAD (2013) highlighted that an increased GVC participation contributes toward per capita GDP growth in both developed and developing economies. A similar view can be found in WTO (2019), which argued that increased GVC participation contributes toward growth in emerging economies such as South Korea and China. Meanwhile, GVCs can also improve industrial development. (UNCTAD, 2013; Kummritz, 2016). However, these studies focused on the positive and linear effects of GVC participation. Recently, the negative effects of GVC have been proposed by Blažek (2015). The dynamic view of GVC participation development that expressing the evolution process of domestic value added (DVA) for GVC participation explained the GVC participation decline (more DVA) over the course of economic growth (Taguchi, 2014). Furthermore, Lee et al. (2018) presented an "In-Out-In again" GVC participation, depicting its non-linear path by using case studies. This study attempts to investigate the effects of GVC on economic growth at the national level and upgrading in GVC at the sectoral level by using quantitative studies with cross-country data.

Since a sector owns a specific knowledge base, technologies, and inputs, GVCs of every sector vary by different knowledge types, explicit and tacit knowledge (more explicit or more tacit knowledge). This sector specific knowledge is associated with the sectoral innovation system (SIS) (Malerba, 2004). The SIS influences the catch-up at the sectoral level. Jung and Lee. (2010) found out that the total productivity factor (TFP) catch-up is more likely to occur in the electrical sector rather than the auto sector because the electrical sector's technopoles are more explicit and easily embodied in imported equipment. This study also attempts to investigate different GVCs and the productive density in different SISs.

## 1.2. Structure

This study is organized as follows. Chapter 1 introduces the motivation and objectives of this study. The overview of GVCs can be found in Chapter 2. Chapter 3 discusses the non-linear relationship between GVCs and economic growth at the national level. Chapter 4 demonstrates the non-linear pattern of GVCs to sectoral upgrading in productivity. Chapter 5 analyzes the different sectoral GVCs based on different SISs. Chapter 6 summarizes and concludes the study.

# Chapter 2. An Overview of GVC

## 2.1. Background of GVC

### 2.1.1. New Globalization

Figure 2-1 shows a decline in costs accompanying technological progress in the developmental phases of globalization. In the pre-globalized world, costs associated with trade, communication, and face-to-face meetings were higher, which resulted in the bundling of economic activities in a small-scale community. After the industrial revolution, since the early 19th century, there has been a steady and significant growth in the share of trade in GDP (Kaplinsky and Morris, 2000; Baldwin, 2016). The transportation industry developed rapidly based on the steam engine technology, reducing trade costs. This reduced the necessity to produce goods close to their point of consumption, leading to an unbundling of economic activities. This was called the period of first unbundling or old globalization by Baldwin (2016). The second unbundling or the so-called new globalization occurred recently due to the ICT revolution. This led to a new wave of globalization wherein the production activities were separated because of lower trade and communication costs. The international separation of these activities shifted many production stages to the latecomers (Baldwin, 2016), offering developing economies opportunities to join global production.

Notably, in this new era of globalization, there has been a rise in intermediate goods trade, which has impacted the existing trade theories and the measurement of trade indexes. In this regard, one notable issue is the double counting parts in gross exports, which could bias estimates of empirical trade analyses. Linden et al. (2007) present a double-counting case of iPod production in China. In the case of iPod production, while the value-added created in China comprised only about $3.86, the double counting led the trade deficit between China and the US increased by about 150 dollars (the factory cost).

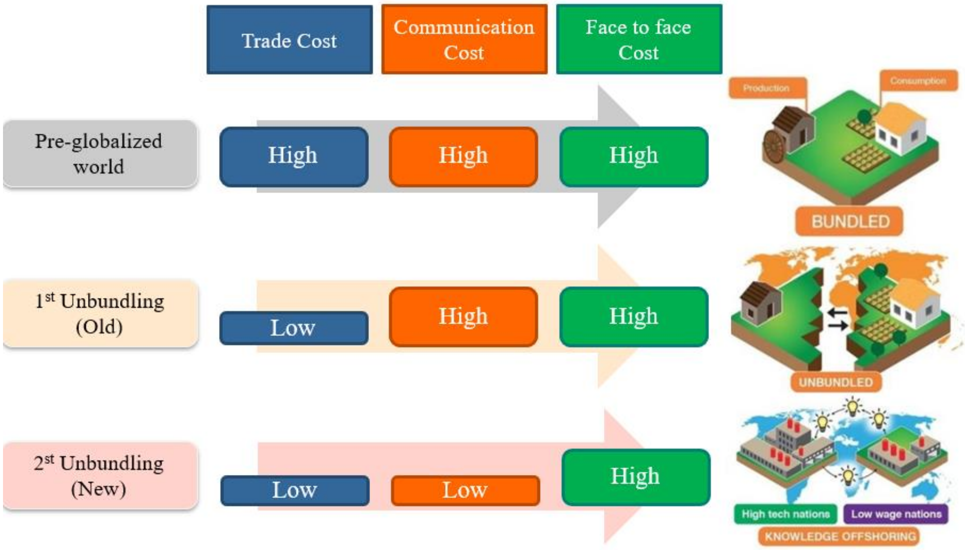


Figure 2-1: Three cascading constraints of globalization

*Source: Author's adaption based on Baldwin (2016)*

### 2.1.2. Trade Theories

Inomata (2017) drew a general map of analytical frameworks for GVCs, as shown in Figure 2-2.

Inomata (2017) points out that the new globalization has questioned the last premise of the three classic premises[1]: countries trade only final products. This is because the feature of new globalization (Baldwin, 2016) is characterized by a rise in the intermediate goods trade via offshoring (Milberg and Winkler, 2013). Therefore, the contemporary GVC research has led to the reconstruction of the trade theory. In GVCs, different stages of the production process, such as design, R&D, assembly, and marketing, are located across different countries. GVC is classified into segments (Timmer et al., 2014) to analyze the production fragments and trade in tasks (Grossman and Rossi-Hansberg, 2008).

[1] The three classic premises as follows: 1) Markets are perfectly competitive, and producers operate at constant returns to scale; 2) an industry consists of homogeneous producers; and 3) countries trade only final products—traditionally based on the example in which Portuguese wine is traded for English cloth—and each product is made using the production factors of only the exporting country. (Inomata, 2017)

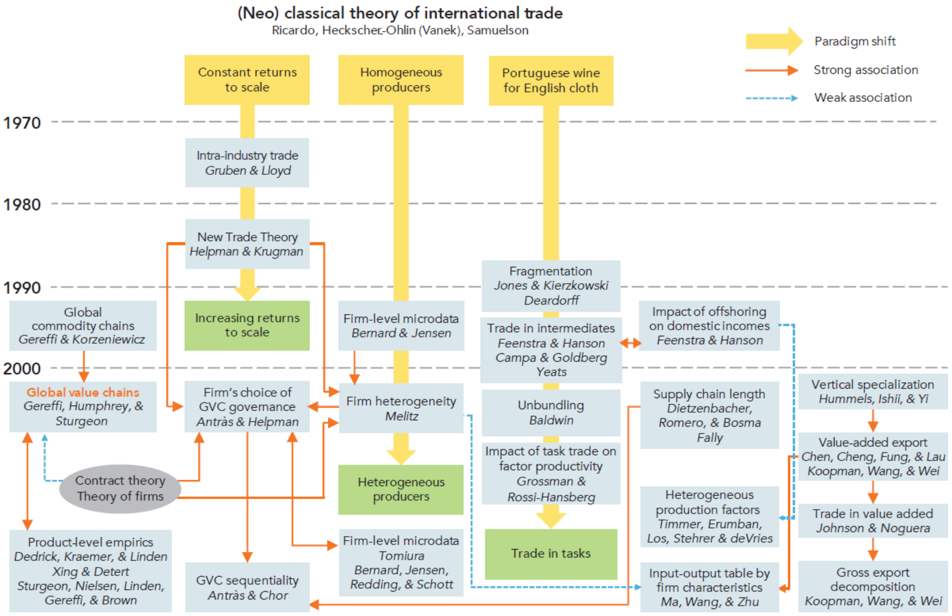


Figure 2-2: Genealogical map of analytical frameworks for global value chains

*Source: Inomata (2017)*

It should be noticed that GVC is not a branch of trade research. It involves multi-research fields including management, human capital, regional research, environmental protection, social science, inequality, economic development, innovation, policy, and other research areas (Kaplinsky and Morris, 2000; UNCTAD, 2013).

## 2.2. Concepts of GVC

### 2.2.1. Descriptions of GVC

A GVC is a supply chain that encompasses the full range of production or service activities across different countries. There are two configurations of GVCs that link the fragmented production processes. A value chain is shown in Figure 2-3. Baldwin and Venables (2013) introduce two basic forms, “spider” and “snake.” Spiders comprise multiple limbs (parts) that join to form a body (assembly) for the final product itself or a component (such as a module in the auto-industry); snakes involve a sequential chain in which intermediate goods move from upstream to downstream, with value added at each stage. Most production processes are complex mixtures of the two aforementioned forms. Therefore, GVC should be identified as a network or a system.

Global commodity chain (GCC), presented by Gereffi and Korzeniewicz (1994), was introduced earlier, but its concept is similar to that of GVC. Gereffi (1994) presents buyer- and producer-driven chains by identifying a lead firm in each GCC. In the buyer-driven chain, large retailers, brand-name merchandisers, and trading companies play the leading role. The buyer-driven chain is represented by labor-intensive industries, such as garments, footwear, toys, consumer electronics, housewares, and hand-crafted items. In a producer-driven chain, multinational enterprises (MNEs) and large integrated industrial enterprises play the dominant role. Producer-driven chain is characterized by capital- and technology-intensive industries, including automotive, information technology (IT), aircraft, and electrical machinery industries. Nevertheless, the boundary of the GCC-type is unclear owing to the complexities of the value chain. Footwear was considered a buyer-driven industry in Gereffi (1994). However, there was a change in the classification after the introduction of the smart factory classification system, drive the chain in the producer side. The IT industry was part of the producer-driven chain; however, now, it embodies both producer- and buyer-driven governance due to the increased power on the buyer side. For example, DELL company controls the PC value chain as an MNE buyer. Although the classification of buyer- and producer-driven GCC chains seems old and crude, the method is helpful to simplify complex economic phenomenons. Taken together, the analysis of a transaction refers to a buyer's view or a producer's view (seller view).

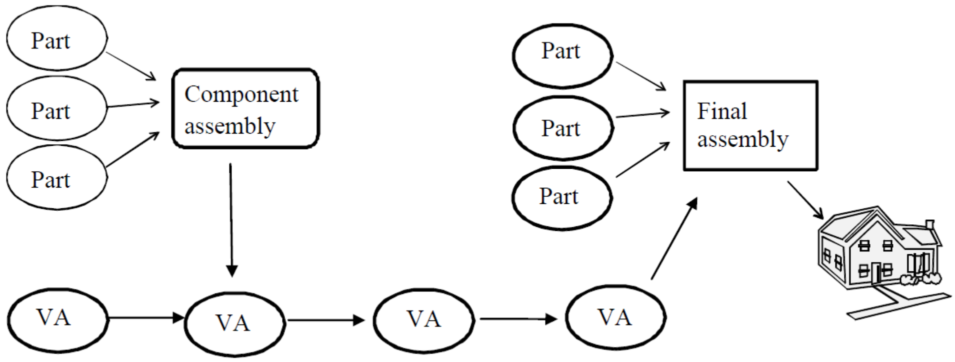


Figure 2-3: Spiders and snakes

*Source: Baldwin and Venables (2013)*

### 2.2.2. GVC Governance

The GCC framework cannot cover the various network forms owing to the growing complexity of value chains. Thus, Gereffi et al. (2005) present the following five types of GVC governance structures, as a new GVC framework for analysis, as shown in Figure 2-4: market, modular value chain, relational value chain, captive value chain, and hierarchy; they range from low to high levels of power asymmetry.

(1) Markets. In the market mode, transactions are easily codified and suppliers engage in production, independent of buyers (lead firms); in this mode, market governance can be expected. Arm's-length trade occurs in the mode by following market prices.

(2) Modular value chains. In modular value chains, the ability to codify specifications extends to complex products, and suppliers exhibit a high potential to produce modules. Since the production of modular components is standardized, the components can be matched with those of different buyers. International outsourcing is the main production path in this mode.

(3) Relational value chains. The core of relational value chains should be mutual dependence. Suppliers exhibit a high potential, which drives lead firms to gain access to complementary competencies via international outsourcing. This mode involves more tacit knowledge than the above two modes. The exchange of

tacit knowledge facilitates frequent face-to-face interaction and is governed by high levels of explicit coordination, increasing switching costs.

(4) Captive value chains. In the captive value chain, suppliers exhibit low capabilities, even though the ability to codify and the complexity of product specifications are high. Lead firms possess more power in this mode. Captive suppliers are frequently confined to a narrow range of tasks, such as simple assembly tasks, and they are dependent on the lead firm for complementary activities, such as design, logistics, component purchasing, and the upgradation of process technology.

(5) Hierarchy. Among the five types of GVC governance, lead firms possess the highest controlling power in the hierarchy mode. In this case, the foreign direct investment (FDI) mainly drives the GVC integration.

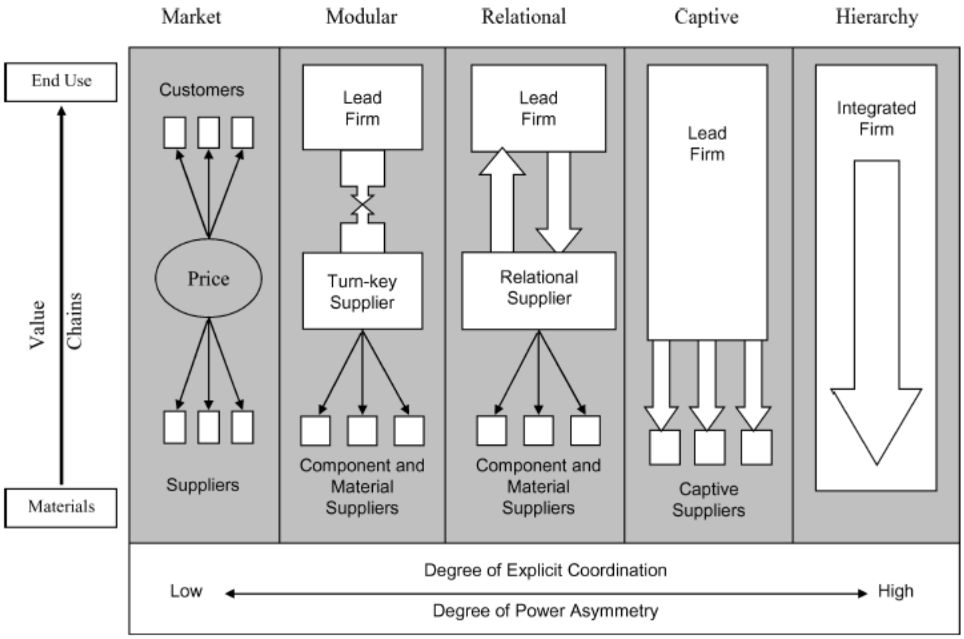


Figure 2-4: Five global value chain governance types

*Source: Gereffi et al. (2005)*

### 2.2.3. GVC Upgrading

GVC offers opportunities for upgradation. Humphrey and Schmitz, (2002) explain the following four type upgrading:

(1) Process upgrading: It refers to transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technology.

(2) Product upgrading: It refers to transitioning to more sophisticated product lines; it can be defined in terms of increased unit values.

(3) Functional upgrading: It refers to acquiring new functions (or abandoning existing functions) to increase the overall skill content of activities. It involves an upgradation from own equipment manufacturer (OEM) to own design manufacturer (ODM), and, finally, to own brand manufacture (OBM) (Hobday, 2003).

(4) Inter-sectoral upgrading: It refers to the progress of a cluster of firms to new productive activities.

## 2.3. An Empirical Analysis of GVC

### 2.3.1. Measurement of GVC

A firm can participate in international production sharing in the following four ways (Wang, 2017):

(1) Exporting its domestic value-added embodied in intermediate exports used by a direct importer to manufacture products for domestic consumption;

(2) Exporting its domestic value-added embodied in intermediate exports used by a direct importer to produce products for a third country;

(3) Using other countries’ value-added to produce its gross exports;

(4) Using other countries’ value-added to develop products for domestic use.

The above ways of engaging in GVCs can be associated with the following four GVC participation indicators: (1) domestic value-added used in foreign consumption as the share of intermediate goods, (2) domestic value-added embodied in foreign exports as the share of intermediate goods, (3) the share of foreign value-added in gross exports (FVA), and (4) domestic value-added embodied in foreign exports as a share of gross exports (DVAFX). The first and second indicators are the newest indicators, measured by Wang (2017), and the last two indicators are conventional GVC indicators introduced by

Hummels (2011). Obviously, there are more than four GVC participation indicators; for example, value-added in gross outputs is another GVC indicator.

It was perplexing to use the above measurement method for performing an empirical analysis for GVC until Hummels (2011) presented the method to measure the GVC participation indicator by using the input-output table. Thus, the empirical approach for GVC study started later. Earlier, the value-added analyses were based on firms' business records (Inomata 2017). Recently, the empirical analysis for GVC research employed a cross-section database due to inter-country input-output (ICIO) The table is published by the Organisation for Economic Co-operation and Development (OECD) and big GVC databases have been built. Popular GVC databases include OECD-TiVA, UNCTAD-Eora, and WIOD.

The earlier study measured firms' GVC participation by using business records. Dedrick et al. (2010) analyze the value chain of four representative products— Apple's iPod and video iPod and Hewlett Packard's and Lenovo's laptop personal computers—by measuring the value-added in production process based on business reports. However, in a short time, it is difficult to obtain enough observations from multiple companies to run regression by using information from business reports. The custom database is a big database for measuring a firm's GVC participation. Lv et al. (2017) estimated a Chinese firm's GVC participation by using a custom Chinese database and matched GVC data to China Industry Business Performance Data to investigate the relationship between GVC and firm performance.

The measurement of the GVC position and the length of GVC are also important topics in the field of GVC, belonging to a broader issue on how to map GVC (Antràs et al., 2012; Fally, 2012).

### 2.3.2. Main GVC Participation Indicators

There are several GVC participation indicators. OECD-TiVA offers 42 indicators referring to GVC and trade, which includes the level and share of GVC participation indicators. There are still other GVC indicators out of the list of OECD-TiVA database. It is difficult to discuss all GVC participation indicators in one research. The popular GVC participation indicators include forward linkage (downstream) GVC indicators, backward linkage (upstream) GVC indicators, and a combination of both forward and backward linkages' GVC indicator.

The backward and forward linkages in GVC respect the upstream and downstream of GVCs, from the perspectives of a producer (seller/exporter) and an user (buyer/ importer) (Wang et al., 2017). The backward participation index captures the extent to which domestic firms use foreign intermediate value-added for export activities in a given country. The forward GVC participation index captures the extent to which firms use a given country's exports in partner countries as export inputs (Kowalski et al., 2015). OECD (2017) defines the backward participation in GVCs as the foreign value embodied in exports; it can be expressed as the percentage of the total gross exports of an exporting country. The forward participation in GVCs is defined as the domestic value embodied in foreign exports; it can be expressed as the percentage of the total gross exports of the source country. However, Wang et al. (2017) express backward GVC participation as the percentage of a country's final goods production contributed by both domestic and foreign factors involving cross-country production sharing activities. Conversely, the forward GVC participation is expressed by the domestic value-added, which is embodied in the inputs sent to the third economies for further processing and exports, as a share of the sector value added (GDP). Therefore, the backward and forward linkages in GVCs can be indicated by different indicators. This research uses the share of total gross exports as the GVC participation indicator because exports growth has been identified as an important influencer of economic growth for developing economies (Balassa, 1978; Ramanayake and Lee, 2015).

Moreover, the re-exported intermediate imports (REII), as the share of total intermediate imports, is another backward linkage GVC indicator that must be investigate in the constitution of intermediate imports. REII indicates how much of the intermediate imports is exported. As a share of intermediate imports, REII is different from the above GVC indicators, which are measures of GVC participation in exports. Thus, REII indicates the processing trade while an economy produces at a low-value added end.

This research selected the share of foreign value added in exports (backward linkage) to investigate the non-linear relationship between GVC participation and economic growth. Lee et al. (2018) present an N-shaped non-linear relationship between GVC participation and economic growth and they indicate that the key to this non-linear relationship is how to build local capabilities. Import-driven (foreign value added) spillovers play a crucial role in enabling developing economies to learn by doing/using. Backward linkage in GVC is positively related to a country's, particularly the developing countries, innovation outcome (Tajoli and Felice, 2018). Furthermore, the forward linkage of GVC would impact economic growth through different mechanisms, as a supplier to others. The effects of a forward linkage will be small when an economy has less global competitivity as a developing economy. Hence, the forward linkage is not considered to provide the non-linear path of development in GVC.

### 2.3.3. Reviews on Empirical Literature

Most empirical literature selected the conventional GVC participation indicator, the share of foreign value added in gross exports (FVA), to run the regressions. It should be noted that most literature focuses on the linear relationship between GVC participation and related variables, as Table 2-2 shows.

One trend of empirical research on GVC is how to determinate GVC participation. Taguchi (2014) verifies the inverse U-shape relationship between DVA (1-FVA) and per capita GDP in Asia with a simple regression, excluding control variables. Lee et al. (2018) link the national innovation system to national level GVC participation and point out that more local knowledge less FVA by using cross-country panel data. They also provide empirical evidence to demonstrate the U-shaped non-linear effects of economic growth on GVC participation (FVA). Although the effects of GVC participation on economic growth has been discussed in Lee et al. (2018) using a case study, the empirical evidence on GVC participation is lacking. The research on sectoral-level GVC participation determination can be found in Del Prete et al. (2018) and Beverelli et al. (2015). Beverelli et al. (2015) analyze the role of domestic value chains (DVCs) for GVCs and find that DVCs can either be stepping stones or obstacles for GVCs. However, the research on control variables is found to be lacking as only import traffic is considered to be the control variable, while many factors can determinate GVC participation. Del Prete et al. (2018) provide the sectoral empirical evidence of the effects of foreign direct investment (FDI) and traffic on backward and forward linkages in GVC; however, they only focus on GVCs of North African countries. Criscuolo and Timmis (2018) and Kowalski et al. (2015) also conduct empirical research to determine both backward and forward GVC participation. Criscuolo and Timmis (2018) focus on firm-level analysis, and Kowalski et al. (2015) provide the national-level evidence. Kowalski et al. (2015) comprehensively consider and analyze the factors that determine GVC participation; these factors are classified into non-policy factors, core trade and investment policy-related factors, and other policy-related factors. In Kowalski et al. (2015), the effect of the level of foreign value added on per capita domestic value has been verified. Nevertheless, only the linear relationship is discussed in their research.

Another strand of empirical research on GVC is how GVCs impact economic growth, upgrading, job creation, and innovation system, among others. Here, I focus on the effects of GVC on economic growth and upgrading. Fagerberg et al. (2018) investigate the effects of GVC participation on economic growth; they find that countries that increase GVC participation do not grow faster than other countries. Fagerberg et al. (2018) do not consider the endogeneity between GVC and economic growth, and the estimation method is simple. Kummritz (2016) and Kummritz et al. (2017) provide empirical evidence for sectoral GVC and find that GVC increases DVA and productivity on both backward and forward side. However, Kummritz (2016) does not consider any control variable. The problems associated with control variables have been improved in Kummritz et al. (2017); however, all sectors are considered together when running regressions by using the fixed-effect estimation. This approach fails to present an analysis for each subsector.

Table 2-1: Empirical literature reviews

| **Article** | **Dependent variable** | **Main explanatory variable** | **Result** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Fagerberg et al. (2018) | Growth of GDP per capita | Share of **FVA in GDP** | Negative linear<br>Not significant |
| Kummritz (2016) | Value of DVA<br>(sectoral level) | **Backward and forward linkage** | Positive linear |
| Kummritz et al. (2017) | Value of DVA | **Backward and forward linkage** | Positive linear |
| Kordalska et al. (2016) | Productivity growth (sectoral level) | Share of **FVA** (in gross export/**final goods/ intermediate goods**) | Positive and significant in the manufacturing sector |
| Taguchi (2014). | Share of DVA in gross export (1- the share of FVA) | Per Capita GDP | Inverse U-shape |
| Lee et al. (2018) | Share of **FVA in gross export**<br>(national level) | Self-citation | Negative and significant |
| Beverelli et al. (2015) | Share of **FVA** in gross export (sectoral level) | Share of inputs in production (sectoral level) | Positive and significant |
| Del Prete et al. (2018) | Value of **FVA** and value of DVA<br>(sectoral level) | FDI share<br>Tariff faced | Positive linear (North Africa) |
| Criscuolo and Timmis. (2018) | Share of **FVA** in gross export (backward linkage) and **forward linkage** | Firm productivity | Positive but not significant (backward)<br>Positive significant (forward) |

| | | | |
|---|---|---|---|
| Kowalski et al. (2015) | **Backward participation and forward participation** | Non-policy factors,<br>Core trade and investment policy-related factors,<br>and other policy-related factors | Linear relationship |

## 2.4. Locked in Low Value-added End: OEM trap

Hobday (2003) introduces the OEM, ODM, and OBM. Lee et al. (2018) pointed out that the dependence on a dominant FVA would present an OEM trap; they also provide a case study to explain the successful catch-up of Hyundai and its consequent upgrading from OEM to OBM by following the non-linear GVC participation path. Further, they analyze the development of Brazil shoe industry by comparing GVC depended on group and independence group.

The high- and low value-added activities can be checked in the following Apple’s value chain (Figure 2-5), presented by Grimes and Sun (2016). The core components, which have a high-cost, include the display, printed circuit board (PCB), integrated circuit (IC)/discrete devices, optical modules, electroacoustic components, internal memory, and hard disk/CD-ROM. The core components are produced in Japan, the US, Korea, and other economies. The low-cost non-core components include connector, function and structure components, peripheral devices, battery, and passive device. The assembly process has been offshored to OEM/ODM companies, such as Hon Hai Precision Industry Co. Ltd. (Foxconn), Pegatron, Flextronics International Ltd., and other companies. Apple, as the lead firm governing the value chain, is cautious in not allowing the supplier to become a competitor (Humphrey and Schmitz, 2000). Foxconn, one of the biggest assembling companies to Apple, is still stuck at OEM/ODM stage without further functional upgrading.

Now, the gaps between high- and low value-added activities have become bigger than those in the 1970s (Figure 2-5). Today, in order to catch-up, it is essential for latecomers to avoid getting stuck at the low end (OEM trap) and upgrade in GVC.

## 2.5. Conclusions

This chapter introduces the background of GVCs and emphasize the new wave of globalization and the development history of trade theories. Subsequently, the concepts of GVCs and its indicators are discussed. This discussion of GVCs indicators explains how to select a GVC indicator for specific research, among several main GVCs indicators. I also summarized results and the dependent and main explanatory variables selected in previous empirical articles. The backward linkage of GVC, particularly the share of FVA in exports, is predominantly used to indicate GVC participation in previous research. Finally, the OEM trap is proposed for explaining the trap in the low value-added end of GVCs. Hence, how to avoid or how to get away from the trap in the low value-added end of GVCs should be an important issue in the research on GVCs. Owing to the OEM trap, the path of GVC participation would be non-linear.

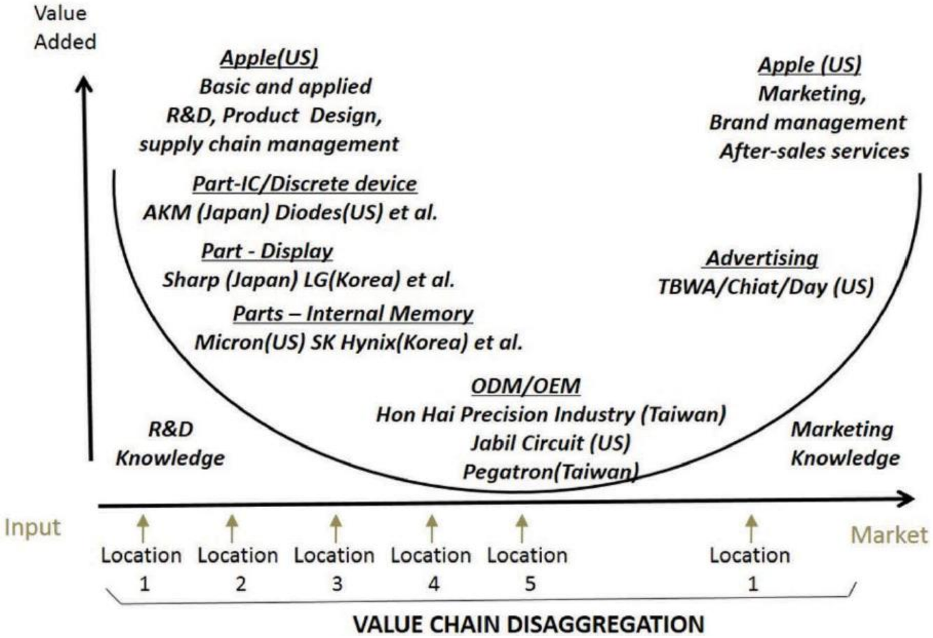


Figure 2-5: Apple's smiling curve and GVC

*Source: Grimes and Sun. (2016)*

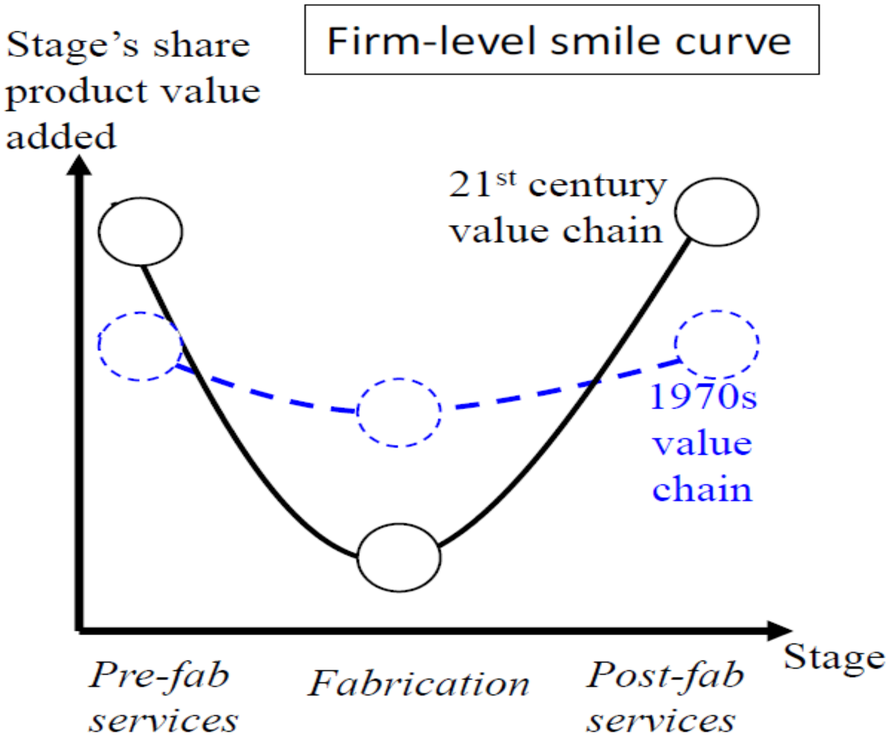


Figure 2-6: Firm-level smile curve.

*Source: Baldwin et al. (2014)*

# Chapter 3. Economic Growth and GVCs

## 3.1. Introduction

GVCs have led to a considerable rise in intermediate trade, in this era of the new globalization based on the ICT revolution (Baldwin, 2016). In GVCs, production activities have been separated internationally. The fragmentation of production in GVCs has reshaped not only the trade of goods and services but also the cross-border movement of know-how (technology), investment, and human capital (Taglioni and Winkler, 2016). These facts are well-known as the main impacts on economic growth. Therefore, GVCs provide an important and powerful view to analyze economic growth. This research aims to investigate the effects of GVC on economic growth by quantitative studies.

The literature on the relationship between GVCs and economic growth is increasing due to economic globalization. Most of them emphasize the contribution of GVC toward economic growth (UNCTAD, 2013; WTO, 2019). Lee et al. (2018) present an "in-out-in-again" non-linear pattern of GVC participation by considering firm cases of upgrading. The "in-out-in-again" hypothesis expressed that, "at initial stage of growth by a latecomer, increased participation in the global value chain (GVC) is necessary to learn foreign knowledge and production skills, that functional upgrading at middle-income stage requires effort to seek separation and independence from existing foreign-dominated GVCs, and that latecomer firms and economies might have to seek reintegration back into the GVC after establishing their own local value chains." Following the non-linear pattern, this study proposes a non-linear hypothesis on economic growth within the GVC. The hypothesis states that an increased GVC participation hinders upgrading (economic growth) when knowledge acquisition enables latecomers to break away from foreign domestic value chain to build local value chain; however, it indicates that an increased GVC participation increases gains and promotes economic growth. This is facilitated by the lopsided market power in GVC and an increase in competitiveness gained after moving to a better position through upgradation from low value-added end to high value-added end.

GVC participation has been measured by the input-output table, since Hummels et al. (2001) presented the methodology to measure the share of FVA in exports, a well-known GVC participation indicator. Exports consist of FVA, which are imported, and DVA produced in domestic countries. Thus, the share of FVA in exports plus the share of DVA) in exports should equal 1. An increase in FVA (less DVA) implies increased GVC participation. This research uses FVA as an indicator of GVC participation.

This study provides empirical evidence on the role that GVCs play in promoting economic growth in the middle- and high-income economies by using 63 cross-country and 16 years balance panel data. This study draws on two major databases—OECD-TiVA (2016 version) and Penn World Table 9.0. This study applies the panel data econometric techniques, such as the fixed-effect (FE) and system GMM estimations, to control for the omitted variable and endogeneity biases. Furthermore, concerning the endogeneity problem along with GVC and economic growth, the GVC participation and economic growth are estimated by a three-stage squares (3SLS) in a system called simultaneous equation model (SEM).

## 3.2. Literature Review

### 3.2.1. Effects of GVCs Participation on Economic Growth

This section discusses the effects of GVCs participation on economic growth. As per one view, there are marginal effects of GVC participation on economic growth. As per Fagerberg et al. (2018), countries that increase their GVC participation do not grow faster than others. However, most literature claimed that an increased GVC participation contributes toward economic growth (UNCTAD, 2013; WTO, 2019). Recently, unlike the positive linear effects view, by using case studies, Lee et al. (2018) propose that the "in-out-in-again" N-shaped GVC participation pattern can bring more successful catch-up.

While some scholars mentioned that international production has increased trade and the division of capital and labor, which is unlike the current scenario (Mankiw and Swagel, 2006), others argued that GVCs have altered the thinking and the organization of industries and national economies (Gereffi, 2014). This is because GVCs are characterized by the international movement of economic factors, such as know-how (technology), investment, and human capital, affecting the economies involved (Taglioni and Winkler, 2016).

Particularly, GVCs offer developing countries opportunities to participate in the global economy without requiring them to develop a whole value chain (Baldwin, 2011). Furthermore, latecomers can draw on foreign knowledge (technology) from GVCs to promote innovation (De Marchi, 2018) and catch-up via learning by doing or learning by using (Lee, 2013). Both the lead and supplier firms can improve quality and cost-effectiveness via GVC to obtain win-win result (Risselada, 2015).

The framework of upgrading in GVCs introduced by Humphrey and Schmitz (2004) is an important tool to analyze GVCs. Upgrading "focuses on the strategies used by countries, regions, and other economic stakeholders to maintain or improve their positions in the global economy" (Gereffi, 2015). However, upgrading in GVC is not automatic. Giuliani et al. (2005) reveal that although process or product upgrading occur, functional and inter-sectoral upgrading are rare phenomena. The reason could be that while GVCs foster product and process upgrading, they prevent functional upgrading (Pietrobelli and Rabellotti, 2011; Blažek, 2015). A successful catch-up model would be upgrading from producing low value-added goods to producing high value-added goods (functional upgrading) or upgrading by successive entries into new industries (Lee and Mathews, 2012). Since hindering functional upgradation would lead to the trap, it is evident that facilitation of functional upgrading would lead to growth.

Another concept of GVCs associated with upgrading is governance in GVCs. This concept "focuses on lead firms and the organization of global industries" (Gereffi, 2015). The key is that the power exerted by a lead firm in GVCs shapes the distribution of profits and risk in an industry. The five types of governance that ranges from high- to low levels of power asymmetry are hierarchy, captive mode, relational mode, modular mode, and market mode. The economies occupying a good position in GVCs would dominate GVCs.

### 3.2.2. Effects of Economic Growth on GVCs

The GVC participation in developed countries is higher than the global average value, while the GVC participation in developing countries is lower than the global average value (UNCTAD, 2013). However, Taguchi (2014) illustrates the dynamic evolution process of domestic value-added creation for GVCs' participants; the author also reports positive correlations between GVCs' participation and per capita GDP square term, which indicate Asian country's GVC participation becomes non-linear with economic development. The estimation results for the GVC participation determination model in Lee et al. (2018) also verify the non-linear relationship between GVC participation and economic growth. Milberg and Winkler (2013) discuss the non-linear effects of economic growth on GVCs participation in chapter 8. The non-linear effects of economic growth have gained acceptance due to empirical evidence.

### 3.2.3. Estimation and the Trends of GVC Participation

Earlier research on GVCs only focused on case studies; the shortage of methods for measuring GVC participation limited the quantitative study. In order to supply the gap, Hummels et al. (2001)[2] present a methodology to measure the share of FVA, a well-known GVC participation indicator, by using the input-output table. Exports consist of FVA parts, which are imported, and DVA parts, which are produced in domestic countries. Thus, the share of FVA in exports plus the share of DVA in exports should equal 1. An increase in FVA (less DVA) implies an increased GVC participation.

The values of FVA are available from the OECD-TiVA[3] database for selected years (1995–2011) and selected economies, including OECD countries and other major economies. The long historical values of FVA are available, which simplifies the observation of facts regarding GVC and furthers the empirical study. Earlier

[2] The method introduced by Hummels et al. (2001) for measuring FVA by using input-output table can be found in Appendix A.
[3] This research used 2016 version of OECD-TiVA. Although the newest version has been published since 2018, the 2018 version covered less historical data (2005-2015) than the 2016 version and the change of statistic standard leads the difficulty to match these two versions.

values of FVA of specific economies can be calculated if the historical input-output tables of those economies are made available.

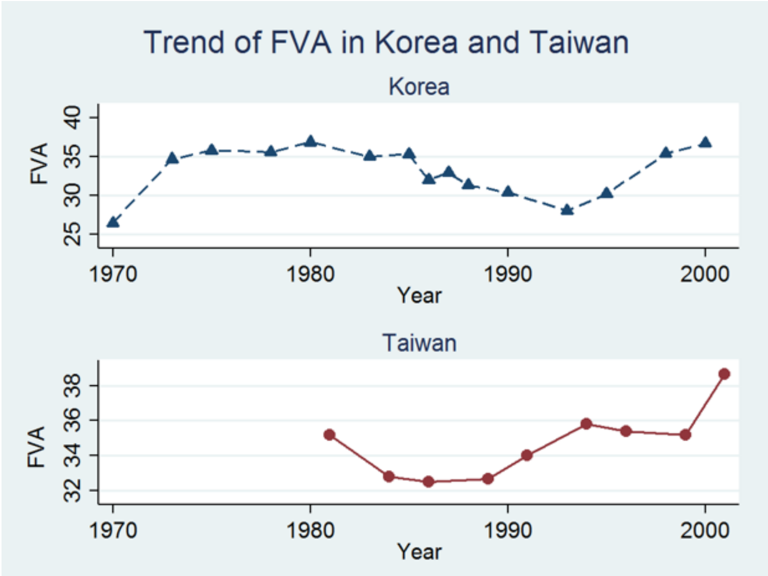


Figure 3-1: Trend of national level FVA in Korea and Taiwan.

*Source: Lee et al. 2018*

Lee et al. (2018) present the trend of FVA estimated using the input-output table data of Korea and Taiwan; the estimation reveals that the period of rapid technological catch-up in Korea corresponds to the period of decline in FVA in Korea from the mid-1980s to the mid-1990s. As shown in Figure 2-1, the trend of FVA in Korea increased after the country integrated into the GVC; subsequently, it decreased during early 1980 to the mid-1990s and then increased again after joining the OECD countries. A similar period of decline in FVA can also be observed in Taiwan through Figure 3-1. Moreover, as shown in Figure 3-2, the trend of FVA in China followed a similar non-linear pattern with Korea with some lags (approximately 15—20 years). Functional upgrading can be observed during the period of decline in FVA in the above three economies (Lee et al., 2018). These successful catch-up economies grew rapidly by following the non-linear GVC participation pattern. Therefore, the decline in the period of GVC participation improved growth in the middle stage of economic growth; in other words, the effect of GVC participation has not always been positive on economic growth in these successful catch-up economies.

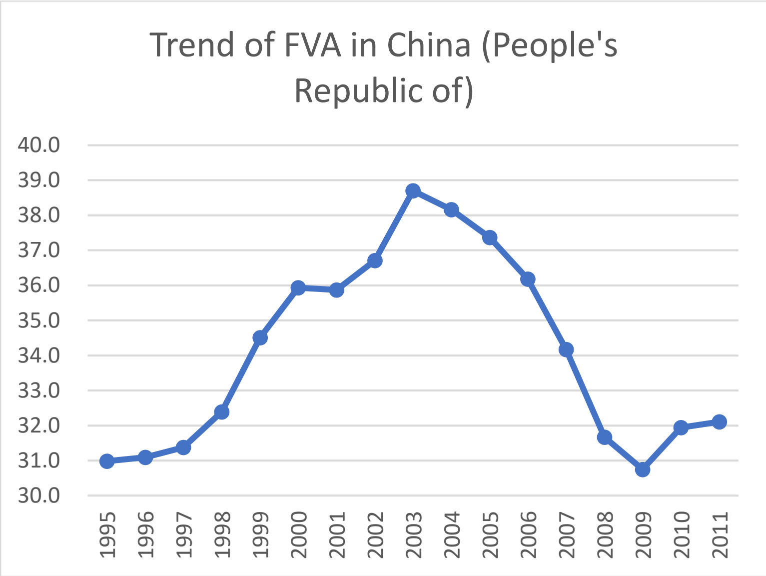


Figure 3-2: Trend of national level FVA in China.

*Source: Author's calculation and OECD-TiVA*

In order to show more general facts of GVC and economic growth, Figure 3-3 depicts the non-linear relationship between the FVA and GDP per capita for middle- and high-income economies during 1995–2010. This figure verified that less FVA (more DVA) would improve economic growth in the middle stage, and, subsequently, more FVA (less DVA) would contribute to the per capita GDP in the next stage. In Figure 3-3, the per capita GDP in advanced economies, such as Korea and Taiwan, increases with an increase in FVA; the per capita GDP in emerging economies, such as Brazil, Indonesia, Thailand, and Philippines, declined the FVA increased in the earlier phase. Subsequently, the per capita GDP in Brazil, Indonesia, and Philippines increased again, while FVA in the above economies witnessed a decline. The relationship between FVA and per capita GDP were positive at a later phase in Thailand. Thus, the declining pattern of GVC can be easily traced in emerging economies.

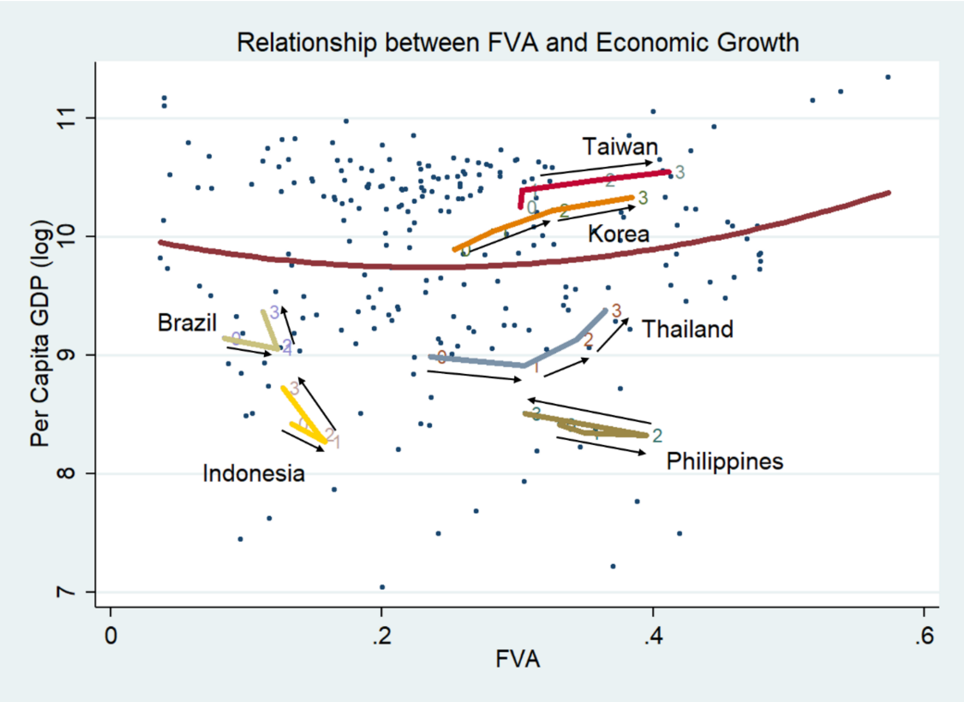


Figure 3-3: The relationship between GVC participation and economic growth.

*Source: OECD-TiVA and Penn World Table 9.0*

Note: Period 0, 1, 2, and 3 correspond to 1995-1998, 1999-2002, 2003-2006, 2007-2010. Observations in the figure are four years average values.

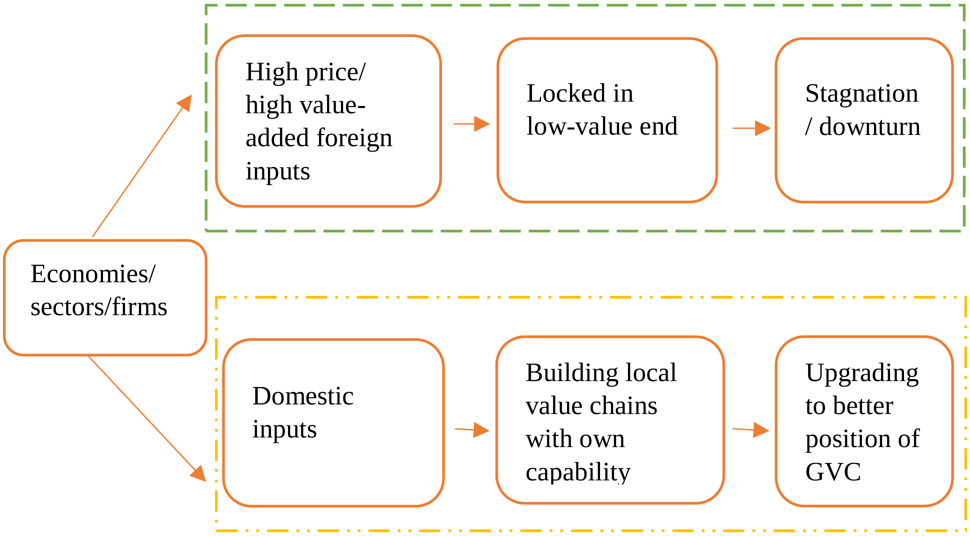


Figure 3-4: Two options, Two paths.

*Source: Author's creation*

A possible mechanism is reported in Figure 3-4. In the first stage, it is recommended that latecomers integrate into the GVC to learn by doing (Baldwin and Yan, 2014). However, the knowledge (technology) spillover from GVC is limited to functional upgrading. Consequently, latecomers face the following two options: maintain reliance on GVCs (foreign inputs) or transfer to a local value chain (domestic inputs). The dependence on a foreign domestic value chain results in the low value-added trap and further leads to economic stagnation, even downturn or downgrading (Lee et al., 2018; Blažek, 2015). However, building local (domestic) value chains with your capability (knowledge) facilitates upgradation to a better position in GVC, thereby leading to economic growth (Lee et al., 2018). After moving to a better position in GVC, an increased GVC participation would imply an increase in benefits due to the market power of latecomers governing the GVC (Gereffi et al., 2005).

Based on the facts and mechanism of the non-linear relationship between GVCs and economic growth, I propose a hypothesis stating that increased GVC participation hinders the economic growth of latecomers after they acquire sufficient learning from the GVC and develop own capability to break away from the foreign domestic value chain (to build local value chains); an increased GVC participation implies more benefits and would promote economic growth, after firms upgrade from a low- to high value-added end. The non-linear hypothesis is summarized in Figure 3-5.

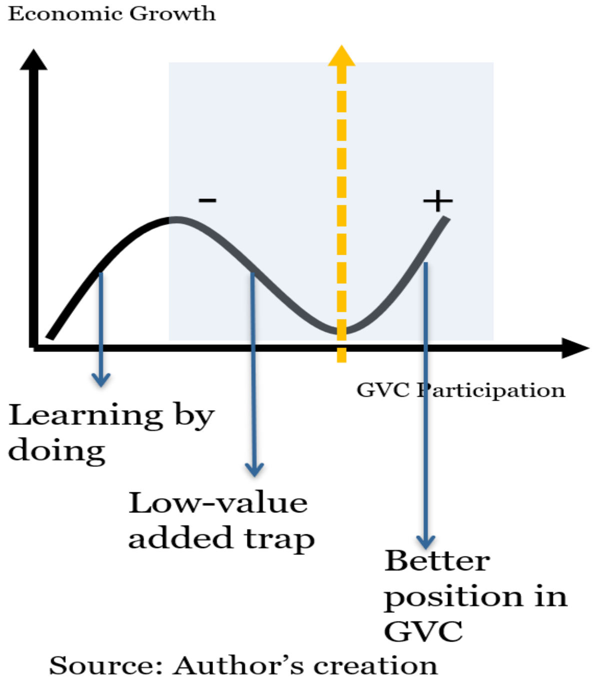


Figure 3-5: Hypothesis of non-linear effects of GVC on economic growth

## 3.3. Methodology and Data

### 3.3.1. Economic Growth Model

The pooled ordinary least squares (OLS) is a classical estimation method for analyzing developmental issues. This method works well to interpret the time-invariant variables, but it can cause an omitted variable bias when analyzing country-specific variables.

Moreover, this estimation method assumes that all dependent variables are strictly exogenous, which is almost impossible in the real economic system. A fixed-effect (FE) panel approach is useful to reduce the omitted variable bias caused by the country-specific aspect. Furthermore, this study used the system generalized method of moments (GMM) to control endogeneity and reduce the omitted variable bias. Thus, the fixed-effect panel, the system GMM method, and the cross-sectional approaches can be found in this study.

In order to verify the effects of GVC on economic growth, I ran both linear and non-linear regressions by using the economic growth model.

The typical linear economic growth model [4]specification is represented by the following equation:

$$PCGDP_{it} = \alpha_1 + \beta_1 PCGDP\_in_{\ it} + \beta_2 GVC_{it} + \theta_1 Z_{it} + \nu_i + \tau_t + \varepsilon_{it} \qquad 3\text{-}1$$

, where i indexes country, and t indexes period; $PCGDP_{it}$ denotes the logarithm of per capita GDP and $PCGDP\_in_{\ it}$ denotes the logarithm of per capita GDP in the initial year of t period. $GVC_{it}$ is the share of foreign value added in gross exports (FVA) as the GVC participation measure; $Z_{it}$ represents a vector of control variables including the logarithm of years of total schooling, population growth rate, and investment per GDP; $\nu_i$ represents a country-specific effect, $\tau_t$ represents a period-specific effect; and $\varepsilon_{it}$ denotes the error term.

I added the square term based on the above economic growth equation to build the following non-linear economic growth equation:

$$\begin{aligned} PCGDP_{it} = \alpha_1 &+ \beta_1 PCGDP\_in_{\ it} + \beta_2 GVC_{it} + \beta_3 GVC_{it}^2 + \theta_1 Z_{it} + \nu_i \\ &+ \tau_t + \varepsilon_{it} \end{aligned} \qquad 3\text{-}2$$

The added term, $GVC_{it}^2$ represents the square of FVA.

### 3.3.2. Simultaneous Equation Model (SEM)

GVC participation and economic growth are considered endogenous variables due to their interactive influences. These two endogenous variables should be considered in one system comprising simultaneous equations, the so-called

[4] This growth model derived from the endogenous growth model has been used in several empirical studies to analyze economic growth (Acemoglu et al., 2001; Barro and Lee 1994). This study followed the growth regression model from Lee and Kim. (2009).

simultaneous equation model (SEM). The SEM model, including the economic growth equation and GVC participation equation, is represented as follows:

$$\begin{aligned} PCGDP_{it} &= \alpha_1 + \beta_1 PCGDP\_in_{\ it} + \beta_2 GVC_{it} + \beta_3 GVC_{it}^2 + \theta_1 Z_{1it} + \nu_{1i} \\ &\quad + \tau_{1t} + \varepsilon_{1it} \\ GVC_{it} &= \alpha_2 + \beta_4 GVC\_in_{it} + \beta_5 PCGDP_{it} + \beta_6 PCGDP_{it}^2 + \theta_2 Z_{2it} + \nu_{2i} \\ &\quad + \tau_{1t} + \varepsilon_{2it} \end{aligned} \tag{3-3}$$

, where i indexes country and t indexes period; $PCGDP_{it}$ is the logarithm of per capita GDP and $PCGDP\_in_{\ it}$ denotes the logarithm of per capita GDP in the initial year of period t; $GVC_{it}$ is the share of foreign value added in gross exports (FVA) as the GVC participation measure, and $GVC\_in_{it}$ represents the FVA in the initial year of period t; $GVC_{it}^2$ is the square term of FVA and $PCGDP_{it}^2$ is the square term of the logarithm of per capita GDP $Z_{1it}$ represents a vector of control variables for the growth model, and $Z_{2it}$ represents a vector of control variables for the GVC participation determination model; $\nu_i$ represents a country-specific effect, and $\tau_t$ represents a period-specific effect; and $\varepsilon_{it}$ is the error term.

Zellner and Theil (1992) introduce the three stages least squares (3SLS) to solve the SEM. This estimation method is asymptotically more efficient than the 2SLS method. The estimation error of the 2SLS method is used to construct the statistic of the random disturbance covariance matrix, and it is iterated to higher stages until convergence; the resulting estimates are identical with maximum likelihood estimates. Therefore, the generalized least squares estimation (GLS) is performed on the whole estimation method, and 3SLS presents a special case of multi-equation GMM where the set of instrumental variables is common to all equations. In this study, I use STATA order “reg3” to do the 3SLS estimations.

### 3.3.3. Data and Variables

This study used the cross-country panel data from 1995 to 2010. I divide the data into four 4-year sub-periods (1995-1998, 1999-2002, 2003-2006, and 2006-2010). This division intends to increase panel balance and reduce the serial-correlation of dependent variables. This method is also commonly used to observe the long-term tendency.

The dependent variable is a log of per capita GDP estimated by using expenditure-side real GDP at chained purchasing power parity rates (PPPs) (in constant 2011 US dollar terms) and population from the Penn World Table 9.0. The main variable of interest is FVA from OECD-TiVA (2016 version). Other control variables include a log of per capita GDP in the initial year of each period, a log of years of total schooling, the share of trade in GDP (openness), the population growth rate, and the investment per GDP. Descriptive statistics and correlations are reported in Appendix C.

## 3.4. Regression Results

### 3.4.1. A Non-linear Pattern of GVC to Economic Growth

Table 3-1 reports the regression results based on the pooled OLS, fixed-effect estimation, and system GMM method. The coefficients of FVA are not significant in the linear models (model 1, 3, and 5). Nevertheless, the coefficient of both FVA and FVA square terms are significant in the non-linear models (model 2, 4, and 6). This result illustrates the difficulty in inferring whether the effect of GVC on an economy is linear. The positive and significant coefficients of square term verify the effects of GVC on economic growth, which may be exhibiting a U-shaped non-linear pattern. In the system GMM, the results of the Hansen test and the second-order serial correlation are both satisfactory.

Using the coefficients of FVA and FVA square, the turning point of the GVC, from negative effect to the positive effect, can be calculated. The turning points of GVC estimated from OLS, fixed-effect, and system GMM model are similar. They are 0.34, 0.32, and 0.31 in the OLS, fixed-effect, and system GMM models, respectively.

In order to control the endogeneity bias between FVA and FVA square term, I used the average turning point value 0.32 as the condition to separate the total sample into two groups. The separated sample regression results can be found in Table 3-2. The coefficients of FVA are negative and significant based on OLS and GMM results in the group with a low GVC participation (FVA<0.32). In the group with a high GVC participation (FVA>0.32 or FVA=0.32), the symbol of FVA coefficients is positive but not significant in OLS and GMM models. The reason the results of FVA are not significant might be attributed to the small number of observations.

Table 3-1: Using Growth of Per Capita GDP (log) as the dependent variable (Non-linear)

| | (1)<br>OLS | (2)<br>OLS | (3)<br>FE | (4)<br>FE | (5)<br>System GMM | (6)<br>System GMM |
|---|---|---|---|---|---|---|
| Per Capita GDP (log) in initial year | $0.985^{***}$ | $0.984^{***}$ | $0.825^{***}$ | $0.800^{***}$ | $0.976^{***}$ | $0.981^{***}$ |
| | (144.48) | (146.33) | (18.05) | (15.87) | (103.59) | (128.76) |
| FVA | -0.0670 | $-0.376^{*}$ | -0.0531 | $-1.014^{*}$ | -0.0472 | $-0.523^{**}$ |
| | (-1.82) | (-2.47) | (-0.36) | (-2.51) | (-1.07) | (-2.79) |
| FVA square | | $0.560^{*}$ | | $1.563^{**}$ | | $0.844^{**}$ |
| | | (2.32) | | (2.88) | | (2.65) |
| Years of total schooling(log) | -0.00525 | -0.00534 | 0.151 | 0.184 | 0.00718 | -0.0132 |
| | (-0.24) | (-0.25) | (1.15) | (1.41) | (0.21) | (-0.43) |
| Openness | $0.0149^{*}$ | $0.0151^{*}$ | -0.0130 | -0.0255 | 0.0167 | 0.0140 |
| | (2.52) | (2.55) | (-0.57) | (-1.19) | (1.85) | (1.68) |
| Population growth rate | -0.121 | -0.401 | -3.324* | -3.707** | -0.164 | -0.644 |
| | (-0.27) | (-0.90) | (-2.55) | (-2.87) | (-0.22) | (-0.96) |
| Investment per GDP | $0.198^{*}$ | $0.222^{**}$ | $0.435^{*}$ | $0.511^{**}$ | $0.364^{*}$ | $0.332^{*}$ |
| | (2.39) | (2.75) | (2.25) | (2.75) | (2.44) | (2.55) |
| Constant | $0.165^{**}$ | $0.208^{***}$ | $1.354^{**}$ | $1.635^{**}$ | $0.180^{*}$ | $0.244^{**}$ |
| | (3.14) | (3.66) | (2.85) | (3.15) | (2.45) | (3.18) |
| Observations | 252 | 252 | 252 | 252 | 252 | 252 |
| r2 | 0.997 | 0.997 | 0.945 | 0.947 | | |
| AR_2_test | | | | | 0.0645 | 0.0786 |
| Hansen_test | | | | | 0.223 | 0.394 |

*t* statistics in parentheses
$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

Table 3-2: Using Per Capita GDP (log) Growth as dependent variable (Linear)

| | FVA<0.32 | | | FVA>0.32 or FVA=0.32 | | |
|---|---|---|---|---|---|---|
| | OLS M | FE M | System GMM M | OLS H | FE H | System GMM H |
| Per Capita GDP (log) in initial year | 0.986*** | 0.815*** | 0.919*** | 0.991*** | 0.803*** | 0.951*** |
| | (120.12) | (12.32) | (37.09) | (90.03) | (7.78) | (39.96) |
| FVA | -0.144* | -0.361 | -0.290* | 0.0919 | -0.107 | 0.231 |
| | (-2.23) | (-1.36) | (-1.98) | (0.99) | (-0.38) | (1.88) |
| Years of total schooling(log) | 0.00127 | 0.181 | 0.236* | -0.0784* | 0.403 | -0.0596 |
| | (0.05) | (1.35) | (2.02) | (-2.05) | (0.69) | (-0.74) |
| Openness | 0.00642 | -0.0905** | -0.0000845 | 0.0212 | 0.0168 | 0.0677*** |
| | (1.18) | (-2.77) | (-0.01) | (1.73) | (0.46) | (4.17) |
| Population growth rate | -0.441 | -2.800 | -1.217 | -0.963 | -2.683 | -3.165 |
| | (-0.82) | (-1.91) | (-0.72) | (-1.07) | (-0.73) | (-1.50) |
| Investment per GDP | 0.152 | 0.432 | 0.108 | 0.352* | 0.418 | 0.440* |
| | (1.50) | (1.80) | (0.54) | (2.51) | (1.14) | (2.35) |
| Constant | 0.173** | 1.487* | 0.373*** | 0.152 | 0.956 | 0.405*** |
| | (2.83) | (2.29) | (3.70) | (1.52) | (0.64) | (3.44) |
| Observations | 188 | 188 | 188 | 64 | 64 | 64 |
| r2 | 0.997 | 0.936 | | 0.998 | 0.959 | |
| AR_2_test | | | 0.169 | | | 0.375 |
| Hansen_test | | | 0.293 | | | 0.833 |

*t* statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

### 3.4.2. The Interaction of GVC Participation and Economic Growth

In order to reduce the endogeneity between GVC participation and economic growth, I ran the 3SLS regression in the SEM; the regression results are shown in Table 3-3. The coefficients of the square term of FVA and per capita GDP are positive and significant in the non-linear model. The separated sample regression results are also shown in Table 3-3 for comparison. The coefficient symbols of FVA and per capita GDP are negative in the low GVC participation group and positive in the high GVC participation group. All these results demonstrate the non-linear U-shaped effect of GVC on economic growth, that is, less FVA (more DVC) promotes economic growth after latecomers capture a position in GVC, and more FVA (less DVA) promotes economic growth after latecomers move to a better position in GVC.

Table 3-3: Simultaneous equation regression (3sls) results

| | Non-linear Total | | Linear separation sample | | | |
|---|---|---|---|---|---|---|
| | | | FVA<0.32 | | FVA>0.32 or FVA=0.32 | |
| | Per Capita GDP (log) | FVA | Per Capita GDP (log) | FVA | Per Capita GDP (log) | FVA |
| Per Capita GDP (log) in initial year | 0.704$^{***}$ | | 0.811$^{***}$ | | 0.813$^{***}$ | |
| | (18.53) | | (20.17) | | (13.64) | |
| FVA | -4.033$^{***}$ | | -0.0366 | | 0.166 | |
| | (-5.09) | | (-0.17) | | (0.67) | |
| FVA square | 5.781$^{***}$ | | | | | |
| | (4.95) | | | | | |
| FVA in initial year | | 0.744$^{***}$ | | 0.725$^{***}$ | | 0.694$^{***}$ |
| | | (20.92) | | (19.41) | | (12.94) |
| Per Capita GDP (log) | | -0.367$^{***}$ | | -0.00326 | | 0.0291 |
| | | (-3.58) | | (-0.36) | | (1.42) |
| Per Capita GDP (log) square | | 0.0185$^{***}$ | | | | |
| | | (3.34) | | | | |
| Years of total schooling(log) | 0.339$^{**}$ | 0.114$^{***}$ | 0.143 | 0.0272 | 0.545 | 0.0545 |
| | (2.93) | (3.50) | (1.36) | (1.18) | (1.68) | (0.61) |
| Openness | -0.0331 | 0.00174 | -0.0896$^{*}$ | 0.0251$^{*}$ | 0.0146 | 0.00778 |
| | (-1.53) | (0.27) | (-2.00) | (2.21) | (0.60) | (0.91) |
| Investment per GDP | 0.736$^{***}$ | | 0.580$^{***}$ | | 0.334$^{*}$ | |
| | (5.58) | | (3.64) | | (2.28) | |
| Population growth rate | -4.580$^{***}$ | | -2.933$^{*}$ | | -0.304 | |
| | (-3.55) | | (-2.23) | | (-0.15) | |
| Population(log) | | 0.0185 | | 0.0293 | | 0.0570 |
| | | (0.77) | | (1.26) | | (1.35) |
| Inflow FDI | | 0.00289 | | 0.0131 | | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | 0.00275 |
| | | (0.54) | | (0.72) | | (-0.61) |
| Share of manufacture in export | | 0.0475* | | 0.0200 | | -0.0221 |
| | | (1.99) | | (0.85) | | (-0.62) |
| Constant | 2.355*** | 1.504*** | 1.487*** | -0.118 | 0.542 | -0.457 |
| | (5.67) | (3.44) | (3.38) | (-0.88) | (0.57) | (-1.45) |
| Observations | 249 | 249 | 186 | 186 | 63 | 63 |
| r2 | 0.997 | 0.997 | 0.998 | 0.998 | 0.998 | 0.998 |
| Period | Yes | Yes | Yes | Yes | Yes | Yes |
| Region | Yes | Yes | Yes | Yes | Yes | Yes |

*t* statistics in parentheses
$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

## 3.5. Conclusions

This research has investigated the actual effects of GVCs on economic growth in the upper middle- and high-income economies. It attempts to improve the existing methodology in the sense that the study verifies the hypothesis not only by pooled OLS estimations but also by the fixed-effect panel, and system GMM estimations in order to reduce possible biases associated with OLS estimations, such as the omitted variable problem and the endogeneity of explanatory variables. Particularly, this research uses the 3SLS estimations to reduce the endogeneity caused by the effect of economic growth on GVC.

The empirical results from our models show that the square of FVA term exerts a significant positive effect on economic growth. This finding shows that the actual effect of GVC on economic growth could exhibit a U-shaped (parts of N shape) non-linear curve in the upper-middle- and high-income economies. The mechanism would be that a less foreign-dominated GVC would benefit functional upgradation in the middle stage of growth, and an increased GVC participation would be effective for latecomers when seeking benefits at a higher stage of development after they build own local value chain in high- and middle-economies. The study suggests that latecomers should cautiously increase GVC participation when aiming for economic growth, and the key is to be able to increase domestic value-added at some point in the development process.

The limitations are as follows. First, one limitation of this study is the lack of empirical estimation to demonstrate the positive effect of GVC participation in the initial stage. This is attributed to the unavailability of data on low-income economies' GVC participation and the lack of historical data. Second, only one GVC participation indicator is used in this research. There are various GVC participation indicators. However, this study selected only one backward linkage indicator to indicate GVC participation. The forward linkage indicator should may have an influence on sectoral upgradation in another mechanism. The relationship between forward linkage GVC and sectoral upgradation should receive further attention in the future. Addressing all these limitations can provide a direction for further research.

# Chapter 4. GVCs and Sectoral Upgrading in Productivity

## 4.1. Introduction

GVCs have been identified as an important determinant of economic growth, with the rise in intermediate trade. The ICT revolution has brought in a new wave of globalization. In this new wave, latecomers obtain the opportunities to integrate into the global production network. The international separation of production processed has resulted in shifting many production stages to the latecomers (Baldwin 2016), and latecomers have been trying to improve their positions in the global economy. This progress is called GVC upgrading (Gereffi, 2015).

Lee and Mathews (2012) emphasize that functional and intersectoral upgradation are the keys to a successful catch-up model. In other words, GVCs may not automatically facilitate functional upgradation, and, consequently, latecomers might get stuck with low-value-added activities. This represents the case of the middle-income trap (Humphrey and Schmitz, 2004; Lee et al., 2018; Blažek, 2015)

The previous industrial studies mostly focus on the linear and positive relationship between GVCs and economic growth (Formai and Caffarelli, 2015; Kordalska et al., 2016; Neagu et al., 2017). Recently, the non-linear GVC participation pattern has been confirmed at a national level in Lee et al. (2018), which proposed an N-shaped pattern of GVC participation for successful catch-up economies by looking into firm cases of upgradation in Korea and Brazil and the GVC data. The N-shaped pattern indicates that an increased GVC participation is helpful for explicit learning in the initial stage of growth, a less foreign-dominated GVC is essential for functional upgradation in the middle stage of growth, and an increased GVC participation is effective for latecomers when they intend to seek benefits at a higher stage of development after building own local value chain.

This research aims to investigate whether and how the non-linear GVC participation pattern contributes toward productivity upgrading at the sectoral level. This study utilizes the two big industry databases (WIOD and UNIDO), which are matched, respectively, with the trade database (TiVA); it also analyzes nine manufacturing sectors. The empirical analysis in this study uses the sectoral data of upper middle- and high-income economies only. Thus, it focuses on the U-shaped (not the whole N-shaped pattern) hypothesis between the share of foreign value added in gross exports and labor productivity, by using not only pooled OLS but also fixed-effect and system GMM estimations. These estimations address the omitted variables and endogeneity problems. The U-shaped hypothesis is confirmed for most of the sectors with some sectoral variations.

## 4.2. Literature Review

### 4.2.1. Upgrading in GVC

Economic subjects (e.g., firms, organizations, and economies) try to improve their positions in the global economy. This progress is called GVC upgrading (Gereffi, 2015). Humphrey and Schmitz (2002) summarize four types of upgrading—process, product, functional, and intersectoral upgrading—based on skills, capabilities, and comparative advantage.

The definitions of the four types of upgrading from Humphrey and Schmitz. (2002) are as follows:

(1) Process upgrading: It refers to transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technology.

(2) Product upgrading: It refers to transitioning to more sophisticated product lines; it can be defined in terms of increased unit values.

(3) Functional upgrading: It refers to acquiring new functions (or abandoning existing functions) to increase the overall skill content of activities. It involves an upgradation from own equipment manufacturer (OEM) to own design manufacturer (ODM), and, finally, to own brand manufacture (OBM) (Hobday, 2003).

(4) Inter-sectoral upgrading: It refers to the progress of a cluster of firms to new productive activities.

Doubtless, GVCs promote product upgrading and process upgrading (Humphrey and Schmitz, 2004). Nevertheless, GVCs could halt functional upgradation and even lead to passive downgrading (Lee et al., 2018; Blažek, 2015).

Kummritz et al. (2017) proposed four transmission channels to explain why expanding and strengthening GVC participation may lead to higher productivity, based on various buyers and sellers (inputs and demands), innovation emerging from limitation, technology spillover, and investments stimulated by GVC. The above positive effects of GVC have been investigated by several scholars (Keller, 2004; Chiarvesio et al., 2010; Ravenhill, 2014). However, local value chains (LVCs) or domestic value chains (DVCs) directly increase productivity via the innovation system. Lee et al. (2018) demonstrate the negative relationship between the localization of knowledge and GVC participation.

### 4.2.2. Indexes of Productivity

Upgrading refers to increasing productivity. Two different indexes of productivity, labor productivity and total factor productivity (TFP), can be chosen. It is difficult to say which one is the best index to indicate productivity. Both labor productivity and TFP can contribute toward investigating the effects of GVC on productivity. Formai and Caffarelli (2015) use both labor productivity and TFP. While Kordalska et al. (2016) select only TFP, Neagu et al. (2017) select only labor productivity.

This study compared the problem of these two indexes of productivity and selected labor productivity, mainly based on the limitation of data at the sector level.

TFP is defined as the residual efficiency of the output that cannot be explained by labor and capital inputs used in production. Researchers should be cautious of the measurement bias when estimating TFP. This is because different measurement methods could lead to a variation in estimation the. Formai and Caffarelli (2015) pointed out "estimating TFP has always been tricky, as it is a non-observable parameter of the production function." Due to the unavailability of R&D data at a sectoral level, a part of TFP growth caused by R&D is difficult to control in this study. The effects of R&D on TFP could be attributed to the effects of GVC.

The measure of labor productivity is much clearer than TFP. The definition of labor productivity is the ratio of output to labor inputs. This leads us to the following three questions: 1) what measure must be used for outputs, 2) what measure must be used for deflating current dollars to dollars in a specified base year, and 3) what measures should be used for labor inputs. In this research, we selected value-added as outputs and the number of employees as labor inputs. GDP deflators (2010 constant)[5] are used to calculate the real price of value added, which is obtained from the UNIDO database; price levels of gross value added (1995=100) are used to calculate the real price of value added, which is obtained from the WIOD.

## 4.3. Estimation and the Trends of GVC Participation at the sectoral level

Sectoral level FVA can be calculated based on methodology in Hummels et al. (2001). This methodology measures the share of FVA in exports (FVA), by using the input-output table. Exports consist of FVA, which are imported, and the components of DVA, which are produced in domestic countries. Thus, the share of FVA in exports plus the share of DVA in exports should be equal 1. An increase in FVA (less DVA) implies increased GVC participation. This research uses FVA as the indicator of GVC participation.

The values of sectoral FVA are available from OECD-TiVA database for selected years (1995-2011) and selected economies,[6] including OECD countries and other major economies. The long historical values of FVA are available, which simplifies the observation of facts regarding GVC and furthers the empirical study. Earlier values of FVA of specific economies can be calculated if the historical input-output tables of those economies are made available.

Figure 4-1 shows the trends of machinery sector's FVA in Korea and Taiwan, and Figure 4-2 shows the trends of transportation sector's FVA in Korea and Taiwan. The trends of the above sector's FVA follow a non-linear pattern, which declines before increasing again, similar to the trends of the national FVA in Korea and Taiwan.

[5] GDP deflators are collected from the Word Development Indicator database.
[6] The list of economies can be found in Appendix B.

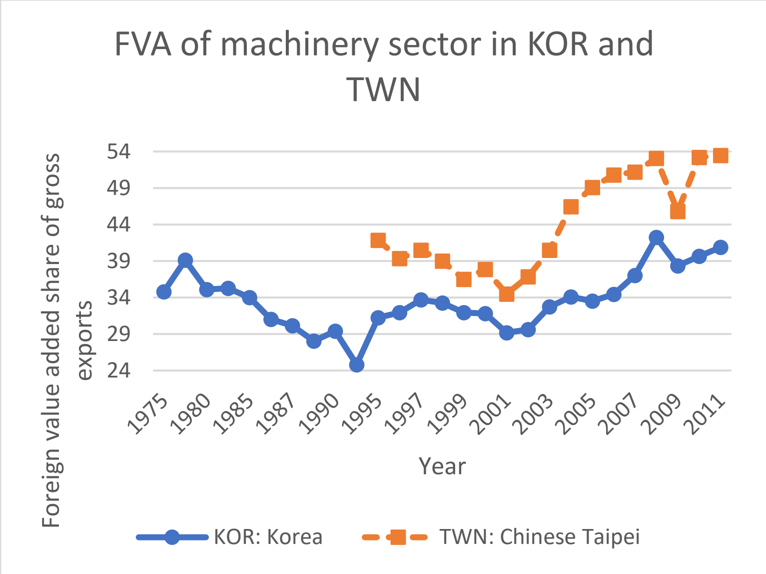


Figure 4-1: Trend of machinery sectoral FVA in Korea and Taiwan

*Source: Author's calculation and OECD-TiVA*

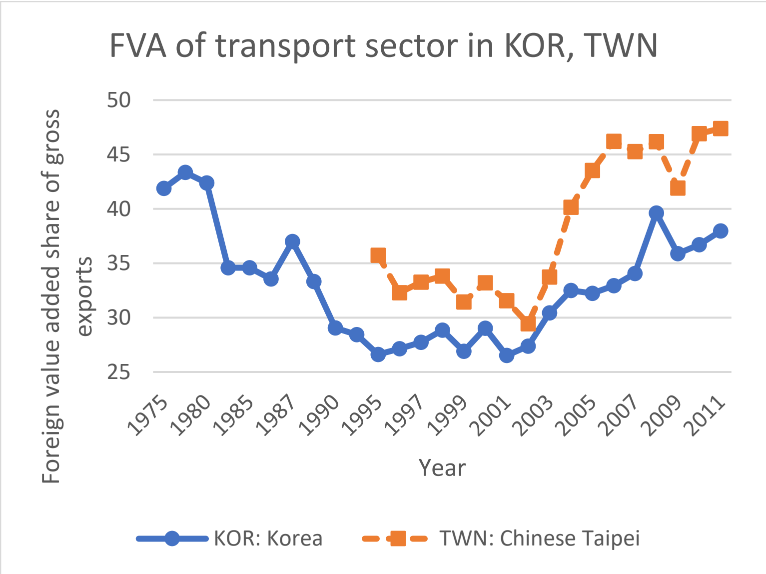


Figure 4-2: Trend of transport sectoral FVA in Korea and Taiwan

*Source: Author's calculation and OECD-TiVA*

Furthermore, the non-linear relationship between FVA and labor productivity in the middle- and high-income economies[7] are reported in Figure 4-3 (machinery sector) and Figure 4-4 (transportation sector). These figures verify that a low FVA (more DVA) would improve economic growth in the middle stage, wherein the latecomers achieve economic objectives and capture a viable position in the GVC. Subsequently, a high FVA (less DVA) would contribute toward per capita GDP in the next stage.

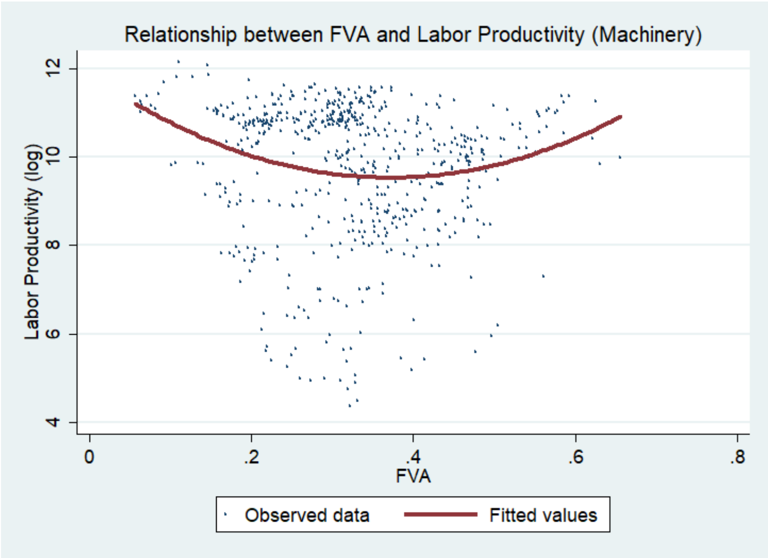


Figure 4-3: Relationship between FVA and labor productivity in the machinery sector

*Source: OECD-TiVA*

[7] Since the low-income economies' FVA is short, the study can only investigate FVA in middle- and high-income economies.

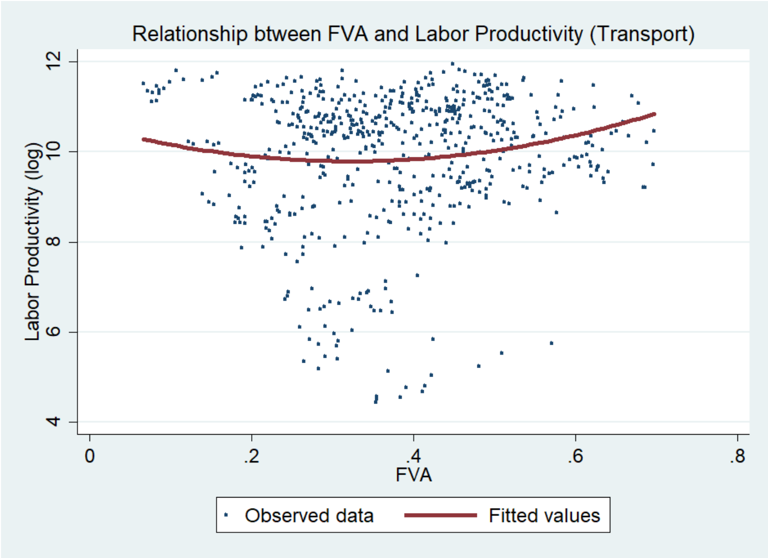


Figure 4-4: Relationship between FVA and labor productivity in the transport sector

*Source: OECD-TiVA*

Facts of sectoral FVA on the non-linear trends of sectoral FVA and non-linear relationships between sectoral FVA and labor productivity are similar to the national level facts. Therefore, the mechanism for establishing non-linear relationships would also be similar. In the first stage, it is recommended that latecomers integrate into the GVC to learn by doing (Baldwin and Yan, 2014). However, the knowledge (technology) spillover from GVC is limited to functional upgrading. Consequently, latecomers face the following two options: maintain reliance on GVCs (foreign inputs) or transfer to a local value chain (domestic inputs). The dependence on a foreign domestic value chain results in the low value-added trap and further leads to economic stagnation, even downturn or downgrading (Lee et al., 2018; Blažek, 2015). However, building local (domestic) value chains with your capability (knowledge) facilitates upgradation to a better position in GVC, thereby leading to economic growth (Lee et al., 2018). After moving to a better position in GVC, an increased GVC participation would imply an increase in benefits due to the market power of latecomers governing the GVC (Gereffi et al., 2005).

Based on the facts and mechanism of the non-linear relationship between GVCs and labor productivity, I propose a hypothesis that a less foreign-dominated

GVC is required for functional upgradation to avoid the low-value-added trap in the middle stage of growth; the hypothesis also suggests that an increased GVC participation is effective for latecomers when they intend to seek benefits in the higher stage of development after building own local value chain in high- and middle-income economies. The non-linear hypothesis is summarized in Figure 4-5.

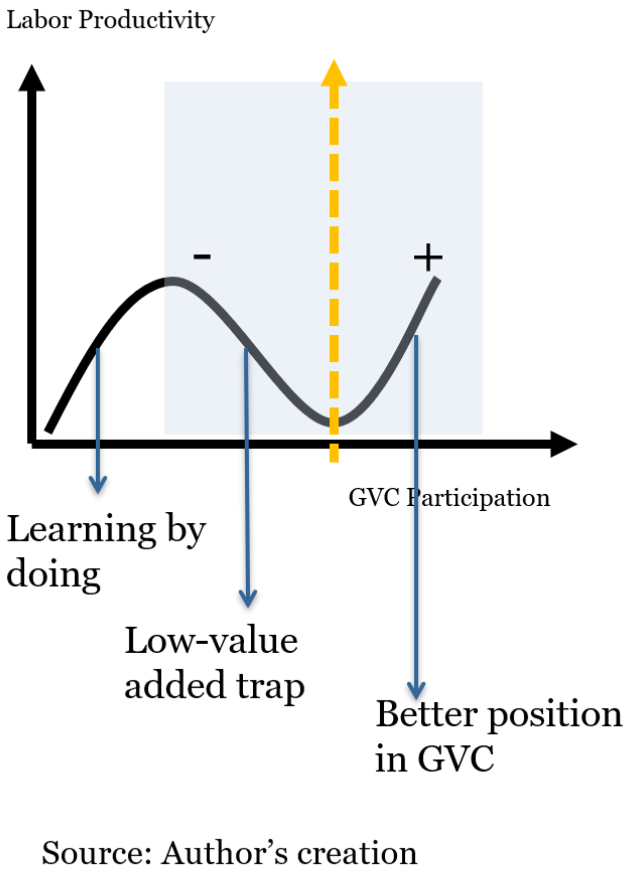


Figure 4-5: Hypothesis of non-linear effects of GVC on labor productivity

## 4.4. Methodology and Data

### 4.4.1. Methodology: Labor Productivity Determination Model

In order to determinate the labor productivity, I used the fixed-effect panel and GMM models, as well as pooled OLS in this research. The labor productivity determination non-linear equation can be formulated as follows:

$$LP_{cit} = \beta_0 + \beta_1 GVC_{cit} + \beta_2 GVC_{cit}^2 + Z_{cit}^T \theta_1 + \mu_c + \nu_i + \tau_t + \varepsilon_{cit} \qquad 4\text{-}1$$

, where c indexes country, i indexes industry, and t indexed time; $LP_{cit}$ is the logarithm of per labor value added indicating labor productivity; $GVC_{cit}$ is the share of foreign value added in gross exports (FVA) as the GVC participation measure; $GVC_{cit}^2$ is the square term of FVA; $Z_{cit}$ [8]represents control variables including the logarithm of per labor capital stock; the logarithm of employee number, the logarithm of real GDP[9], the share of high skilled labor, and the rate of exports in total outputs; $\mu_c$ represents a country-specific effect, $\nu_i$ represents an industry-specific effect, and $\tau_t$ represents a period-specific effect; and $\varepsilon_{cit}$ is the error term.

The logarithm of per labor capital stock is used to control the capital effects; the employee number is used to control the industry size, the real GDP is used to control the domestic market size; the share of high skilled labor is used to control human capita, and the rate of exports in total outputs is used to control how much is learned by export.

The main variables of interest are FVA and FVA square, which are obtained from OECD-TiVA. Other main variables are collected from WIOD. The sectoral data collected from UNIDO is used for the robustness check. The information about WIOD and UNIDO is presented in the next section.

### 4.4.2. WIOD database

This study used WIOD-SEA (2014 version), a part of the World Input-Output Database (WIOD). The socio-economic accounts contain industry-level data on employment (number of workers and educational attainment), capital stocks, gross output, and value added at current and constant prices from 1995 to 2010. This database covers 40 economies, including all OECD countries and other major economies such as China, Brazil, and India. The exchange rate from the Penn World Table 9.0 was used to transfer the current price to the US dollars price in this study.

[8] The control variables used from UNIDO database are different from that present in the WIOD database. This is attributed to the unavailability of data on the capital stock and the share of high skilled labor. I used the GFCF data from UNIDO. Although the capital stock can be calculated by the GFCF, the lack of historical data makes the estimation impossible.

[9] Real GDP is from Penn world table 9.0

Descriptive statistics and correlations are reported in Appendix C.

### 4.4.3. UNIDO database

In this study, value added, employment (number of workers), and gross fixed capital form the gross fixed capital formation (GFCF) data; they are collected from the 2018 UNIDO industrial statistics database, which is a part of the UNIDO database. To obtain the real price of value added and the GFCF, I used the GDP deflator (2010 constant), estimated from the World Development Indicator (World Bank). This study selected 63 economies over the 1995-2010 period to match the OECD-TiVA database covering the same economies over the same period. Although the sectoral database covers more data than WIOD, missing observations exist in the database, which leads to unbalance panel data.

Descriptive statistics and correlations reported in Appendix C. The table summarizing information of WIOD, UNIDO, and OECD database can be found in Appendix D.

## 4.5. Regression Results

### 4.5.1. Regression Results Based on WIOD Database

Table 4-1 presents the regression results using the WIOD dataset, based on OLS. The coefficients of FVA square terms are positive and significant, except the results of the food and metal sectors. The results estimated by the fixed-effect and system GMM estimations are reported in Tables 4-2 and 4-3. In Table 4-2, the coefficients of FVA square terms are positive and significant, except the results of the food and metal sectors. The FVA square terms' results in Table 4-3 are similar to those in Table 4-1. In Table 4-3, the coefficient of FVA square terms is also positive and significant in most sectors, except the food, textiles, paper, and transportation sectors. The results confirm the U-shape relationship between GVC and labor productivity at the sectoral level.

The positive and significant results on the share of the high-skilled labor suggest that high-skilled human capital can improve labor productivity in metal, electric, and transportation sectors. The positive results of real GDP can be observed in all sectors; it implies that large-sized economies have more opportunities to improve labor productivity.

Table 4-1: OLS including the square term (WIOD)

| | (1) Food | (2) Textiles | (3) Paper | (4) Chemical | (5) Metal | (6) Machinery | (7) Electric | (8) Transport | (9) Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | $-6.100^{**}$ | $-5.665^{***}$ | $-11.35^{***}$ | $-7.411^{***}$ | $-5.535^{**}$ | $-9.068^{***}$ | $-6.994^{***}$ | $-14.33^{***}$ | $-8.601^{***}$ |
| | (-2.83) | (-3.56) | (-6.11) | (-4.38) | (-2.62) | (-4.07) | (-4.08) | (-6.71) | (-3.62) |
| FVA Square | 4.729 | $5.721^{**}$ | $12.90^{***}$ | $6.243^{**}$ | 3.562 | $9.961^{***}$ | $6.635^{***}$ | $15.57^{***}$ | $9.830^{**}$ |
| | (1.41) | (2.97) | (5.28) | (3.09) | (1.27) | (3.88) | (4.15) | (6.63) | (3.10) |
| PL capital stock | $-0.659^{*}$ | 0.138 | 0.147 | 0.274 | 0.00641 | 0.248 | $0.779^{***}$ | $0.557^{***}$ | 0.108 |
| | (-2.44) | (0.65) | (1.17) | (1.95) | (0.03) | (1.61) | (5.88) | (6.44) | (0.63) |
| Employee(log) | $-1.633^{***}$ | $-0.596^{**}$ | $-0.492^{*}$ | -0.327 | -0.182 | $-0.728^{***}$ | $-0.329^{*}$ | 0.183 | $-1.123^{***}$ |
| | (-4.14) | (-3.30) | (-2.04) | (-0.88) | (-0.82) | (-3.33) | (-2.02) | (1.40) | (-5.29) |
| Real GDP (log) | $0.826^{***}$ | 0.0973 | $0.630^{**}$ | $0.489^{*}$ | $0.569^{**}$ | $0.861^{***}$ | $0.392^{*}$ | $0.504^{**}$ | $0.828^{***}$ |
| | (4.57) | (0.66) | (3.09) | (2.25) | (2.97) | (4.86) | (1.99) | (3.05) | (3.33) |
| High-skilled labor | 0.00133 | -0.000706 | 0.00471 | $0.0370^{***}$ | $0.0234^{***}$ | $0.0109^{*}$ | $0.0261^{***}$ | $0.0126^{**}$ | -0.00371 |
| | (0.29) | (-0.16) | (0.96) | (6.31) | (3.45) | (2.13) | (5.14) | (2.84) | (-0.67) |
| Export rate | $1.387^{**}$ | -0.782 | -0.820 | 0.146 | -0.130 | $-1.107^{***}$ | -0.419 | $-1.084^{***}$ | -0.245 |
| | (2.93) | (-1.96) | (-1.40) | (0.22) | (-0.25) | (-3.90) | (-1.03) | (-4.42) | (-0.82) |
| Constant | $16.66^{***}$ | $10.87^{***}$ | $4.304^{**}$ | 3.366 | $4.932^{*}$ | 0.682 | -1.434 | -0.561 | $4.431^{*}$ |
| | (4.60) | (4.41) | (3.22) | (1.60) | (1.96) | (0.34) | (-0.86) | (-0.29) | (2.24) |
| Observations | 570 | 570 | 570 | 540 | 570 | 570 | 570 | 570 | 570 |
| R2 | 0.947 | 0.964 | 0.961 | 0.949 | 0.937 | 0.946 | 0.946 | 0.935 | 0.941 |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Table 4-2: FE including the square term (WIOD)

| | (1) Food | (2) Textiles | (3) Paper | (4) Chemical | (5) Metal | (6) Machinery | (7) Electric | (8) Transport | (9) Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | -4.011$^{*}$ | -2.906$^{**}$ | -9.973$^{***}$ | -5.590$^{***}$ | -3.307$^{*}$ | -8.847$^{***}$ | -6.062$^{***}$ | -14.07$^{***}$ | -7.109$^{***}$ |
| | (-2.21) | (-2.64) | (-7.60) | (-5.44) | (-2.36) | (-5.87) | (-5.61) | (-10.62) | (-5.06) |
| FVA Square | 1.981 | 3.585$^{*}$ | 10.78$^{***}$ | 4.259$^{***}$ | 0.634 | 8.957$^{***}$ | 5.931$^{***}$ | 15.19$^{***}$ | 8.140$^{***}$ |
| | (0.67) | (2.53) | (5.69) | (3.55) | (0.38) | (4.89) | (5.60) | (9.96) | (3.91) |
| PL capital stock | -0.522$^{**}$ | 0.161 | 0.225$^{*}$ | 0.472$^{***}$ | 0.104 | 0.251$^{*}$ | 1.100$^{***}$ | 0.696$^{***}$ | 0.237$^{**}$ |
| | (-3.27) | (1.44) | (2.47) | (3.49) | (0.72) | (2.42) | (11.73) | (8.54) | (2.81) |
| Employee(log) | -1.545$^{***}$ | -0.780$^{***}$ | -0.512$^{**}$ | -0.525$^{*}$ | -0.211 | -0.859$^{***}$ | -0.115 | 0.0772 | -1.066$^{***}$ |
| | (-6.90) | (-7.66) | (-3.17) | (-2.50) | (-1.28) | (-6.54) | (-0.92) | (0.69) | (-10.28) |
| Real GDP (log) | 1.392$^{***}$ | 1.235$^{***}$ | 1.089$^{***}$ | 0.972$^{***}$ | 1.048$^{***}$ | 1.075$^{***}$ | 0.975$^{***}$ | 1.035$^{***}$ | 1.467$^{***}$ |
| | (7.60) | (7.32) | (5.60) | (4.94) | (5.06) | (5.92) | (4.89) | (5.25) | (6.85) |
| High-skilled labor | 0.00796 | 0.00627 | 0.00616 | 0.0352$^{***}$ | 0.0208$^{**}$ | 0.00961 | 0.0308$^{***}$ | 0.0130$^{*}$ | 0.00344 |
| | (1.35) | (1.27) | (1.06) | (4.67) | (2.80) | (1.78) | (5.15) | (2.56) | (0.50) |
| Export rate | 1.209$^{**}$ | -0.228 | 0.0703 | 0.659 | 0.141 | -0.721$^{***}$ | -0.176 | -0.620$^{**}$ | 0.377 |
| | (3.08) | (-1.16) | (0.21) | (1.66) | (0.44) | (-3.61) | (-0.79) | (-2.75) | (1.77) |
| Constant | 7.048$^{*}$ | -3.337 | -2.352 | -4.518 | -2.831 | -0.634 | -13.21$^{***}$ | -8.399$^{**}$ | -5.841$^{*}$ |
| | (2.41) | (-1.56) | (-1.07) | (-1.65) | (-0.96) | (-0.25) | (-5.41) | (-3.20) | (-2.15) |
| Observations | 570 | 570 | 570 | 540 | 570 | 570 | 570 | 570 | 570 |
| R2 | 0.377 | 0.447 | 0.391 | 0.391 | 0.312 | 0.541 | 0.543 | 0.451 | 0.493 |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Table 4-3: GMM including the square term (WIOD)

| | (1) Food | (2) Textiles | (3) Paper | (4) Chemical | (5) Metal | (6) Machinery | (7) Electric | (8) Transport | (9) Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | -21.77*** | 1.277 | 11.02*** | -10.89*** | -6.928*** | -10.93*** | -21.78*** | 13.53** | -30.63*** |
| | (-5.18) | (0.96) | (4.23) | (-8.93) | (-4.68) | (-6.43) | (-23.44) | (3.16) | (-7.97) |
| FVA Square | 10.15 | -3.696* | -25.17*** | 5.220*** | 5.701*** | 16.68*** | 21.56*** | -6.899 | 32.85*** |
| | (1.43) | (-2.03) | (-5.28) | (3.62) | (3.47) | (7.35) | (18.61) | (-1.54) | (5.76) |
| PL capital stock | 1.183*** | 1.027*** | 1.770*** | 0.835*** | 0.337 | 2.611*** | 0.979*** | 0.0657 | 1.262*** |
| | (6.19) | (4.21) | (10.37) | (11.47) | (0.94) | (15.22) | (17.10) | (0.39) | (10.47) |
| Employee(log) | -1.068** | -0.944*** | 1.097*** | -2.032*** | -1.364** | 2.226*** | -0.305*** | 0.877*** | -0.476** |
| | (-3.19) | (-6.29) | (4.50) | (-25.71) | (-3.03) | (9.66) | (-4.48) | (4.55) | (-2.97) |
| Real GDP (log) | -0.289 | -0.108 | -2.283*** | 1.762*** | -0.406 | -0.604** | 0.408*** | -2.822*** | -0.519** |
| | (-1.12) | (-1.39) | (-14.14) | (26.98) | (-1.12) | (-3.12) | (4.23) | (-8.77) | (-2.60) |
| High-skilled labor | -0.0396** | -0.0463*** | 0.0750*** | -0.0361*** | 0.170*** | 0.00395 | 0.0227*** | 0.121*** | 0.0715*** |
| | (-3.14) | (-6.02) | (12.41) | (-4.69) | (15.97) | (1.12) | (4.44) | (12.56) | (8.76) |
| Export rate | 24.82*** | -3.830*** | -8.862*** | 3.044*** | -6.364*** | -7.089*** | 1.283*** | -0.255 | -3.964*** |
| | (19.71) | (-18.05) | (-29.12) | (7.23) | (-19.73) | (-17.82) | (5.85) | (-1.11) | (-17.34) |
| Constant | 6.105 | 6.588* | 12.73*** | -8.946*** | 18.27*** | -17.28*** | -1.451 | 35.48*** | 10.45*** |
| | (1.39) | (2.21) | (10.61) | (-15.63) | (5.70) | (-12.65) | (-1.37) | (9.82) | (4.80) |
| Observations | 570 | 570 | 570 | 540 | 570 | 570 | 570 | 570 | 570 |
| AR_2_test | 0.217 | 0.394 | 0.251 | 0.317 | 0.0197 | 0.413 | 0.951 | 0.379 | 0.282 |
| Hansen_test | 0.632 | 0.674 | 0.434 | 0.427 | 0.587 | 0.446 | 0.509 | 0.478 | 0.606 |

*Notes:* *t* statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; P-values are presented for AR (2) and Hansen tests.

### 4.5.2. Regression Results Based on the UNIDO Database

The robustness check is conducted using the UNIDO database. I replaced the data of variable per labor value added, per labor capital stock, and the number of employees by using the UNIDO database; I also ran similar regressions by using the pooled OLS, fixed-effect, and system GMM estimations. The OLS estimation results are reported in Table 4-4. The coefficients of FVA square terms are positive and significant, except the results of the food, textiles, metal, and machinery sectors. Table 4-5 shows the fixed-effect estimation results. In Table 4-5, the OLS estimation results show that the coefficients of the square term are positive and significant in the same sectors. System GMM estimation results can be found in Table 4-6. The GMM estimation results of FVA square term are positive and significant in most sectors, except the paper and electrical sectors. These positive and significant results of FVA square terms confirm the U-shaped relationship between GVC and labor productivity. The results estimated by the UNIDO database confirm that the results estimated by using WIOD are robust.

The positive and significant results of the share of high skilled labor suggest that high skilled human capital can improve labor productivity in electrical sectors, based on the UNIDO database. The positive results of real GDP can also be found in all sectors by using the UNIDO database; it confirms that large-sized economies present more opportunities to improve labor productivity.

Table 4-4: OLS including the square term (UNIDO)

| | (1) Food | (2) Textiles | (3) Paper | (4) Chemical | (5) Metal | (6) Machinery | (7) Electric | (8) Transport | (9) Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | -2.067* | -1.620* | -4.725*** | -2.878*** | -0.902 | -2.616 | -3.528*** | -3.909*** | -2.130 |
| | (-2.04) | (-2.11) | (-4.40) | (-3.52) | (-0.98) | (-1.84) | (-3.93) | (-3.44) | (-1.66) |
| FVA Square | 0.546 | 1.655 | 4.281* | 2.538** | 1.042 | 3.113 | 3.505*** | 4.665*** | 3.147* |
| | (0.31) | (1.67) | (2.46) | (2.83) | (0.86) | (1.53) | (3.78) | (3.69) | (1.99) |
| PL GFCF | 0.189** | 0.0499** | 0.0601** | 0.105*** | 0.0853** | 0.0940** | 0.129*** | 0.123*** | 0.157*** |
| | (3.11) | (2.74) | (2.73) | (3.43) | (3.29) | (2.87) | (5.84) | (3.59) | (4.22) |
| Employee (log) | -0.785*** | -0.264*** | -0.185* | -0.680*** | -0.245* | -0.288** | -0.334*** | -0.0792 | -0.125** |
| | (-9.16) | (-6.17) | (-2.32) | (-3.91) | (-2.37) | (-3.09) | (-5.38) | (-1.16) | (-2.62) |
| Real GDP (log) | 0.295*** | 0.0113 | 0.431*** | 0.762*** | 0.594*** | 0.584*** | 0.469*** | 0.288*** | 0.330** |
| | (3.48) | (0.13) | (5.08) | (7.82) | (6.03) | (6.38) | (5.78) | (3.71) | (3.27) |
| High-skilled labor | -0.0791 | -0.361 | -0.369 | 0.265 | -0.470 | 0.174 | 0.725* | 1.140*** | 0.502 |
| | (-0.28) | (-1.17) | (-0.82) | (0.69) | (-1.35) | (0.54) | (2.42) | (3.97) | (1.49) |
| Export rate | 0.321 | 0.259 | 0.425 | 0.00298 | 0.338 | 0.264 | 0.271 | 0.0639 | 0.184 |
| | (1.84) | (1.76) | (1.31) | (0.01) | (1.36) | (1.86) | (1.67) | (0.33) | (1.23) |
| Constant | 10.17*** | 11.81*** | 6.684*** | 4.430*** | 4.232*** | 4.033** | 5.603*** | 7.325*** | 5.876*** |
| | (9.85) | (9.05) | (5.78) | (3.42) | (3.84) | (3.10) | (5.03) | (6.61) | (4.85) |
| Observations | 455 | 455 | 470 | 435 | 473 | 468 | 469 | 466 | 464 |
| r2 | 0.970 | 0.981 | 0.962 | 0.961 | 0.950 | 0.967 | 0.957 | 0.946 | 0.962 |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Table 4-5: FE including square term (UNIDO)

| | (1) Food | (2) Textiles | (3) Paper | (4) Chemical | (5) Metal | (6) Machinery | (7) Electric | (8) Transport | (9) Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | -1.765 | -0.403 | -4.098*** | -2.509*** | -0.892 | -3.258*** | -3.531*** | -4.102*** | -2.152** |
| | (-1.66) | (-0.63) | (-5.48) | (-4.01) | (-1.28) | (-3.92) | (-5.12) | (-4.98) | (-2.80) |
| FVA Square | 0.154 | 0.400 | 2.869** | 1.871* | 0.355 | 3.540*** | 3.526*** | 4.525*** | 3.307** |
| | (0.09) | (0.49) | (2.65) | (2.54) | (0.41) | (3.51) | (5.15) | (4.80) | (3.01) |
| PL GFCF | 0.180*** | 0.0370* | 0.0506*** | 0.102*** | 0.0796*** | 0.0971*** | 0.121*** | 0.120*** | 0.161*** |
| | (8.34) | (2.47) | (3.41) | (4.35) | (5.04) | (4.72) | (6.06) | (6.41) | (6.58) |
| Employee (log) | -0.785*** | -0.351*** | -0.408*** | -0.830*** | -0.299*** | -0.298*** | -0.377*** | -0.0926* | -0.124*** |
| | (-19.68) | (-10.65) | (-8.23) | (-9.50) | (-5.67) | (-7.18) | (-8.09) | (-1.97) | (-4.93) |
| Real GDP (log) | 0.499*** | 0.386*** | 0.801*** | 1.184*** | 0.778*** | 0.542*** | 0.588*** | 0.294* | 0.297* |
| | (4.54) | (4.16) | (6.72) | (9.04) | (6.55) | (4.78) | (4.45) | (2.03) | (2.21) |
| High-skilled labor | 0.155 | -0.0929 | -0.486 | 0.348 | -0.399 | 0.0567 | 0.766* | 1.313*** | 0.413 |
| | (0.49) | (-0.36) | (-1.61) | (0.91) | (-1.20) | (0.20) | (2.15) | (4.41) | (1.21) |
| Export rate | 0.287 | 0.255* | 0.671** | 0.393 | 0.407* | 0.345** | 0.245 | 0.0909 | 0.197 |
| | (1.39) | (2.42) | (3.06) | (1.77) | (2.49) | (3.02) | (1.85) | (0.69) | (1.82) |
| Constant | 6.985*** | 6.712*** | 2.776 | -0.348 | 1.827 | 4.689** | 4.357** | 6.828*** | 5.825*** |
| | (5.02) | (5.78) | (1.94) | (-0.23) | (1.28) | (3.31) | (2.75) | (3.82) | (3.42) |
| Observations | 455 | 455 | 470 | 435 | 473 | 468 | 469 | 466 | 464 |
| r2 | 0.683 | 0.372 | 0.344 | 0.464 | 0.422 | 0.461 | 0.381 | 0.315 | 0.280 |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Table 4-6: GMM including the square term (UNIDO)

| | (1)<br>Food | (2)<br>Textiles | (3)<br>Paper | (4)<br>Chemical | (5)<br>Metal | (6)<br>Machinery | (7)<br>Electric | (8)<br>Transport | (9)<br>Recycling |
|---|---|---|---|---|---|---|---|---|---|
| FVA | -3.241*** | -2.323*** | 3.750*** | -2.378*** | -11.16*** | -3.787* | 0.151 | -3.146* | -2.921*** |
| | (-4.06) | (-4.14) | (4.41) | (-3.89) | (-6.18) | (-2.31) | (0.10) | (-2.39) | (-8.17) |
| FVA Square | 3.244* | 3.055*** | -4.541** | 3.385*** | 19.15*** | 7.557*** | -1.552 | 7.444*** | 6.491*** |
| | (1.96) | (4.55) | (-3.25) | (5.17) | (8.05) | (3.35) | (-0.94) | (5.30) | (13.11) |
| PL GFCF | 0.151*** | 0.0663*** | -0.0304** | 0.0349* | -0.0109 | -0.157*** | 0.00930 | -0.104*** | 0.0670*** |
| | (8.37) | (6.54) | (-3.22) | (1.99) | (-0.76) | (-4.66) | (0.59) | (-7.26) | (4.91) |
| Employee (log) | -0.894*** | -0.434*** | -0.125*** | -0.171* | -0.370*** | -0.309*** | 0.0986 | -0.0856 | -0.203*** |
| | (-20.21) | (-9.07) | (-4.63) | (-2.03) | (-4.35) | (-5.55) | (1.24) | (-1.75) | (-7.60) |
| Real GDP (log) | 0.688*** | 0.277*** | 0.124** | 0.241*** | 0.520*** | 0.609*** | 0.0669 | 0.321*** | 0.0101 |
| | (11.98) | (9.17) | (2.85) | (3.95) | (6.26) | (10.53) | (1.17) | (3.43) | (0.21) |
| High-skilled labor | -2.638*** | -4.004*** | -0.900** | 2.047*** | -0.862* | 1.136** | 1.534*** | -2.096*** | 0.736*** |
| | (-6.88) | (-12.48) | (-2.99) | (5.78) | (-2.31) | (3.20) | (5.73) | (-6.46) | (3.44) |
| Export rate | 0.761 | 0.257 | -0.346 | -0.514*** | -1.278*** | -0.147 | 1.919*** | 0.646*** | 0.0113 |
| | (1.61) | (1.39) | (-1.49) | (-4.10) | (-4.27) | (-0.75) | (7.92) | (4.17) | (0.09) |
| Constant | 5.880*** | 9.080*** | 9.667*** | 8.663*** | 7.745*** | 5.728*** | 8.474*** | 8.158*** | 10.61*** |
| | (10.32) | (25.04) | (21.76) | (19.48) | (13.57) | (7.05) | (11.87) | (7.21) | (18.39) |
| Observations | 455 | 455 | 470 | 435 | 473 | 468 | 469 | 466 | 464 |
| AR_2_test | 0.983 | 0.460 | 0.509 | 0.249 | 0.750 | 0.220 | 0.249 | 0.276 | 0.553 |
| Hansen_test | 0.980 | 0.854 | 0.728 | 0.757 | 0.852 | 0.960 | 0.947 | 0.860 | 0.837 |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$; P-values are presented for AR (2) and Hansen tests.

## 4.6. Conclusions

This research has investigated the relationship between GVC and upgradation in nine manufacturing sectors in the upper-middle- and high-income economies. It attempts to improve the existing methodology in the sense that the study verifies the hypothesis not only by pooled OLS estimations but also by the fixed-effect panel, and system GMM estimations in order to reduce possible biases associated with OLS estimations, such as the omitted variable problem and the endogeneity of explanatory variables. Particularly, this study compared the WIOD and UNIDO databases, respectively, and it matched the databases with OECD-TiVA for providing significant and robust empirical evidence.

The empirical results from our models show that the square of FVA term exerts a significant positive effect on economic growth. This finding shows that the actual effect of GVC on economic growth could exhibit a U-shaped (parts of N shape) non-linear curve in the upper-middle- and high-income economies. The mechanism would be that a less foreign-dominated GVC would benefit functional upgradation in the middle stage of growth, and an increased GVC participation would be effective for latecomers when seeking benefits at a higher stage of development after they build own local value chain in high- and middle-economies. The study suggests that caution should be exercised when increasing GVC participation with an intention of achieving sectoral upgradation, and the key is to be able to increase domestic value-added at some point in the development process.

Our research is not without limitations. The first limitation of this study is the lack of empirical estimation to demonstrate the positive effect of GVC participation in the initial stage. This is attributed to the unavailability of low-income economies' GVC participation data and the lack of historical data. Second, we do not consider the effect of the service sector on upgradation. The service sector is an important part of economic growth, and service-based GVCs have also witnessed a rapid development. However, WIOD and UNIDO do not present detailed service sector data. Third, only one GVC participation indicator is used in this research. There are various GVC participation indicators. This study selected only one backward linkage indicator to indicate GVC participation. The forward linkage indicator may also have an influence on sectoral upgradation through another mechanism. The relationship between forward linkage GVC and sectoral upgradation should receive further attention in the future. Addressing all these limitations can provide a direction for further research.

# Chapter 5. The Different Sectoral Innovation System (SIS) Productivity and GVCs

## 5.1. Introduction

The new wave of globalization has raised the volume of intermediate trade. Production activities have been internationally separated across different economies. Several economies are integrating into GVCs to participate in the international production network. Furthermore, economies seek higher productivity in sectoral GVCs; particularly, emerging economies expect to upgrade through GVC. Lee et al. (2018) present the N-shaped non-linear path to participate in GVCs effectively. The U-shaped non-linear relationship (not whole N-shaped pattern) between GVCs and productivities has been verified for the upper-middle- and high-income economies in the previous chapter. This chapter attempts to identify the differences in sectoral GVCs in different sectoral innovation systems (SISs), by following U-shaped non-linear patterns in upper-middle- and high-income economies.

Knowledge (technology) is the driver of productivity. Schumpeterian theories emphasize innovation and technological capabilities as the enabling factors for catch-up (Lee, 2013). The SISs are different from the Schumpeterian view because knowledge base, technologies, and inputs are specific (Malerba, 2004). GVCs affect productivity through the innovation system (knowledge spillover). The effects of a sectoral value chain could be different on sectoral innovation productivity. This study attempts to identify the difference in the effects of GVC, based on the specific knowledge of SISs.

Based on the characteristics of knowledge, this study selects the electrical sector (typical explicit knowledge-based sector), machinery sector (typical tacit knowledge-based sector), and transportation sector (typical tacit knowledge-based sector) for conducting further investigations.

This study utilizes the industry databases WIOD and matches it with TiVA; it also conducts an analysis between the explicit knowledge-based sector and the tacit knowledge-based sector. The empirical analysis in this study uses the sectoral data of upper-middle- and high-income economies. Thus, the study focuses on the U-shaped (not the whole N-shaped pattern) GVC participation pattern using the fixed-effect and system GMM estimations. These estimations address omitted variables bias and endogeneity problems. This study also uses dummy variables to examine the differences in different SISs.

Two findings are presented in this study. The first finding is that the explicit knowledge-based sector is more open than the tacit knowledge-based sector. The second finding is that the marginal effect of the GVC on productivity is smaller in the explicit knowledge-based sector and bigger in the tacit knowledge-based sector. To the best of my knowledge, this is the first research that analyzes the difference in sectoral GVCs' effects according to the sectoral innovation system.

## 5.2. Literature Review

### 5.2.1. Sectoral Innovation System

The concept of the sectoral innovation system was introduced by Malerba (2004). Knowledge is one of the main building blocks of the sectoral system of innovation.

Based on the type of knowledge, sectors can be classified into the following two types: more explicit knowledge-based sector or more tacit knowledge-based sector. Explicit knowledge is the knowledge that can be readily articulated, codified, accessed, and verbalized. It can be easily transmitted to others. Conversely, tacit knowledge is the knowledge that is difficult to transfer through written media or verbalization. Jung and Lee (2010) find that TFP catch-up is more likely to occur in the electrical sector rather than the automotive sector because electrical sector's technopoles are more explicit and easily embodied in imported equipment.

Most of the knowledge spillover from GVCs could be explicit; additionally, it is observed that there is a limited scope to learn tacit knowledge from a GVC. Codified information and knowledge can be transferred and linked in national- or international-scale networks (Malmberg and Maskell, 1997), while tacit information and knowledge are best developed and exchanged locally. Local value chains more effectively facilitate the acquisition of tacit knowledge (Lawson and Lorenz, 1999).

Therefore, the explicit knowledge-based sector is more open than the tacit knowledge-based sector.

### 5.2.2. Two Offshoring Ways in GVC: Outsourcing and FDI

Offshoring has led to the relocation of business process between countries. It is a common phenomenon in GVC. There are two offshoring modes—international outsourcing and foreign direct investment (FDI). Outsourcing is an agreement in which one company hires another company to be responsible for a plan internally. FDI may be associated directly with offshoring in the form of international insourcing (Olsen, 2006). Therefore, trade in outsourcing corresponds to inter-firm trade, and trade in FDI corresponds to intra-firm trade (Amador and Cabral, 2014).

Outsourcing is associated with the non-equity modes (NEMs) or arm's-length transactions, referring to four governance modes (modular, relational, captive, and market) introduced by Gereffi et al. (2005), and FDI is commonly referred to as the hierarchy mode, another GVC governance mode introduced by Gereffi et al. (2005). FDI is a case of cross-border vertical integration along GVCs (UNCTAD, 2013). Codifiability is lowest in the hierarchy mode than in other GVC governance modes (Gereffi et al., 2005). In other words, the hierarchy mode is associated with more tacit knowledge, while other modes are associated with more explicit knowledge. Hence, the tacit knowledge-based sector would select FDI, and the explicit-based sector would select outsourcing to integrate into GVC.

## 5.3. Differences in Sectoral GVCs

### 5.3.1. Cases of the Apple and General Motors (GM) Case

Apple Inc. belongs to the explicit knowledge-based sector, as an electronics company. This company located in California produces iPod and iPhone using modular inputs from GVC through outsourcing. Apple's produce, iPod and iPhone, are designed in California and assembled in China. The intermedia inputs are purchased in the global market. For example, in an iPod supply chain, processors mostly belong to the domestic country, hard drives are mainly produced in Japan, Korea's Samsung supplies memories, and batteries are produced in world factories (Dedrick et al., 2010). Let us assume that Apple stops using processors made by

Qualcomm Corporation, a US company, and orders processors from Huawei, a Chinese company, at a lower price. The GVC participation of Apple will become higher. However, the change in GVC participation may marginally affect the labor productivity of Apple.

General Motors (GM) is another US company. GM is in the tacit knowledge-based sector as an automotive company. Sturgeon et al. (2008) indicated that some characteristics of the US automotive industry include rising product complexity, low codifiability (tacit knowledge), and a paucity of industry-level standards. Modular production requires supply chains to maintain an industry-level standard. Therefore, GM invests and builds automotive factories all over the world to facilitate integration. The intermediate goods from overseas factories imported to GM factories in the US are associated with the inside capability of GM. GM can be treated as a national-boundary company through FDI. An increase in GVC participation would imply high imports from overseas factories established by GM. The investment could drive labor productivity in GM.

Comparing the outsourcing-driven GVC (Apple case) with the FDI-driven GVC (GM case), I find that the marginal gain from outsourcing (explicit knowledge-based sector) could be smaller than FDI (tacit knowledge-based sector).

### 5.3.2. Finding out Differences with Non-linear Approach in SISs

In the literature review section, the differences in different SISs can be summarized based on the fact that the explicit knowledge-based sector (e.g. electrical sector) is more open than the tacit knowledge-based sector (e.g. transportation and machinery sector). In this regard, another consideration is that the tacit knowledge-based sector would select FDI, and the explicit-based sector would select outsourcing to integrate into GVC.

Table 5-1 shows that the FVA in the electrical sector (explicit knowledge-based sector) is not smaller than that in the transportation and machinery sectors (tacit knowledge-based sector). The facts imply that the explicit knowledge-based sector is more open. Thus, in this chapter, the first hypothesis states that the explicit knowledge-based sector is more open than the tacit knowledge-based sector.

Table 5-1: The Mean of FVA in the total upper middle- and high-income economies, Taiwan, Korea, and China

| Industry | Total Average | Taiwan | Korea | China |
|---|---|---|---|---|
| Electrical and optical equipment | 0.38 | 0.43 | 0.36 | 0.67 |
| Transport equipment | 0.37 | 0.37 | 0.31 | 0.40 |
| Machinery and equipment | 0.34 | 0.43 | 0.34 | 0.35 |

Furthermore, I compared the outsourcing-driven GVC and the FDI-driven GVC by using Apple and GM case studies and found that the marginal gain from outsourcing (explicit knowledge-based sector) could be smaller than FDI (tacit knowledge-based sector). Therefore, the second hypothesis is that the marginal effect from the explicit knowledge-based sector could be smaller than that from the tacit knowledge-based sector.

Since the actual pattern of sectoral GVC in the upper-middle- and high-income economies may exhibit a U-shaped pattern, which has been confirmed in chapter 4, the use of a non-linear approach to verify the above two hypotheses would be more effective. As shown in Figure 5-1, in order to verify the first hypothesis in the U-shaped non-linear model, it is essential to confirm that the turning point in the explicit knowledge-based sector is higher than that in the tacit knowledge-based sector. To examine the second hypothesis in the U-shaped model, it is important to find whether the slope in the explicit knowledge-based sector is flatter than that in the tacit-knowledge based sector.

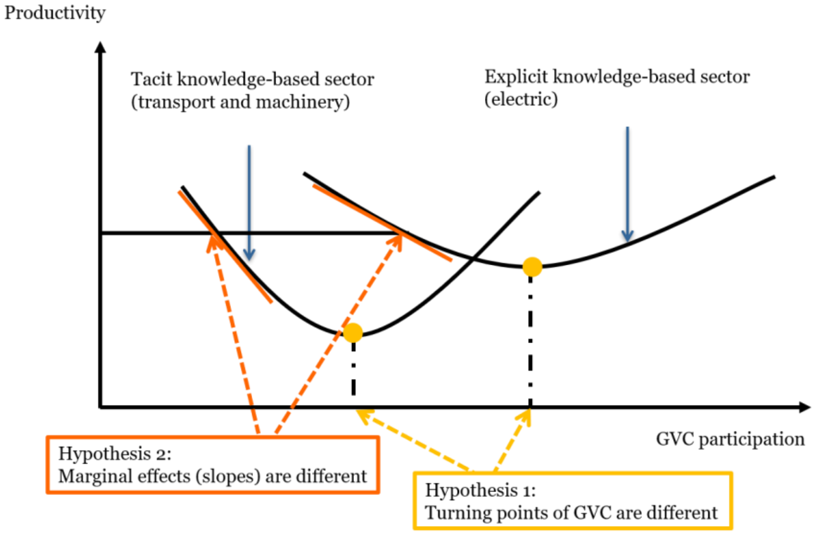


Figure 5-1: Different sectoral innovation system productivity

*Source: Author's creation*

## 5.4. Methodology and Data

### 5.4.1. Labor Productivity Determination Model

The labor productivity determination through the non-linear equation can be formulated as follows:

$$LP_{cit} = \beta_0 + \beta_1 GVC_{cit} + \beta_2 GVC_{cit}^2 + Z_{cit}^T \theta_1 + \mu_c + \nu_i + \tau_t + \varepsilon_{it} \qquad \text{5-1}$$

, where c indexes country, i indexes industry, and t indexed time; $LP_{cit}$ is the logarithm of per labor value added indicating labor productivity; $GVC_{cit}$ is the share of foreign value added in gross exports (FVA) as the GVC participation measure; $GVC_{cit}^2$ is the square term of FVA; $Z_{cit}$ [10]represents control variables including the logarithm of per labor capital stock; the logarithm of employee number, the logarithm of real GDP[11], the share of high skilled labor, and the rate of exports in

[10] The control variables used from UNIDO database are different from that present in the WIOD database. This is attributed to the unavailability of data on the capital stock and the share of high skilled labor. I used the GFCF data from UNIDO. Although the capital stock can be calculated by the GFCF, the lack of historical data makes the estimation impossible.
[11] Real GDP is from Penn world table 9.0

total outputs; $\mu_c$ represents a country-specific effect, $\nu_i$ represents an industry-specific effect, and $\tau_t$ represents a period-specific effect; and $\varepsilon_{cit}$ is the error term.

The logarithm of per labor capital stock is used to control the capital effects, the employee number is used to control the industry size, the real GDP is used to control the domestic market size, the share of high-skilled labor is used to control human capital, and the rate of exports in total outputs is used to control how much is learned by exports.

The main variables of interest are FVA and FVA square, which are obtained from OECD-TiVA. Other main variables are collected from WIOD. I used fixed-effect in this study to correct the omitted variables bias caused by country-specific and industry-specific effects and used system-GMM to reduce the endogeneity bias. Subsequently, the turning point and slope of each sector can be compared by using the estimation results.

### 5.4.2. Model with Dummy Variables

In order to analyze the different productivities of SISs in GVCs, I added a dummy variable to identify the effects of the explicit knowledge-based sector (electrical sector). The estimation equation is expressed as follows:

$$\begin{aligned} LP_{cit} = \beta_0 + \beta_1 GVC_{cit} + \beta_2 GVC_{cit}^2 + \beta_3 dummy * \mathrm{GVC}_{cit} \\ + \beta_4 dummy * GVC_{cit}^2 + \beta_5 dummy + Z_{cit}^T \theta_1 + \nu_i + \tau_t \\ + \varepsilon_{cit} \end{aligned} \tag{5-2}$$

, where c indexes country, i indexes industry, and t indexes time; $LP_{cit}$ is the logarithm of per labor value added indicating labor productivity; $GVC_{cit}$ is the share of foreign value added in gross exports (FVA) as the GVC participation measure; $GVC_{cit}^2$ is the square term of FVA; $dummy$ denotes the electrical industry dummy variable, i.e., dummy equals 1 for the electrical industry, and equates 0 otherwise; $Z_{cit}$ represents control variables including the logarithm of per labor capital stock, the logarithm of employee number, the logarithm of real GDP, the share of high skilled labor, and the rate of exports in total outputs; $\nu_i$ represents a country-specific effect, and $\tau_t$ represents a period-specific effect; and $\varepsilon_{cit}$ is the error term.

The characteristic of electrical sector's GVC pattern can be observed by calculating turning points and comparing the slope with dummy results. The dummy-term's results for identifying the effect of the electrical industry in fixed effect models has been dropped by Stata 14 automatically.

### 5.4.3. Data and Variables

FVA and the rate of exports in total outputs[12] are taken from OECD-TiVA; sectoral level variables include labor productivity, per labor capital stock[13] (capital effect), employee number (industry size), and the share of high-skilled labor human capital) are taken from WIOD; and the market size control variable, real GDP, is obtained from the World Development Indicator (World Bank). The dependent variable labor productivity is estimated by employee numbers and the real-value added.

Descriptive statistics and correlations are reported in Appendix C

## 5.5. Regression Results

Tables 5-1 and 5-2 show the regression results, including FVA square terms, that is, non-linear model results, respectively, by using fixed-effect and system GMM estimations. In each table, seven models are presented for electrical, machinery, transportation, machinery and transportation sectors, comparison between electrical and machinery sector, comparison between electrical and transportation sector, and comparison between the electrical and machinery and transportation sectors, respectively. In the last three models, dummy equals one; additionally, to identify the aforementioned differences, the electrical sectors are compared with the other sectors.

The fixed-effect estimation results, including the FVA square terms, are shown in Table 5-1. In the first four models, the FVA square term of model 1 is the smallest.

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[12] The rate of exports in total outputs is calculated by using exports and outputs data from OECD-TiVA. This variable is used to control the part learning by exporting.
[13] Per labor capital stock is estimated by employee numbers and capital stock from WIOD.

Furthermore, the coefficient of Dummy and FVA square interaction term are negative and significant. It confirms that the marginal gain from the explicit knowledge-based sector (electrical sector) is smaller than that from the tacit knowledge-based sector. The turning points wherein the effects of GVC turn positive from negative are estimated by the regression results in the study.

The GVC turning point of the electrical sector's value chain is 0.51, in model 1; the turning point of the machinery sector's value chain is 0.47, in model 2; the turning point of the transportation sector's value chain is 0.46, in model 3; the turning points are 0.49 for both electrical and machinery sector's value chains, in model 4; in model 5, the turning point of the electrical sector's value chain is 0.49, and the turning point of the transportation sector's value chain is 0.47; in model 6, the turning point of electrical sector's value chain is 0.49, and the average turning point of transportation and machinery sector's value chain is 0.47. The results of the turning point in each sector show that the GVC turning point of the explicit knowledge-based sector (electrical sector) is higher than that of the tacit knowledge-based sector. In order to do the robustness check, system GMM estimation results for the non-linear model are reported in Table 5-2. The turning point in the electrical sector is the highest (0.66), among all other sectors, which implies that the electrical sector (explicit knowledge-based sector) is more open than others (tacit knowledge-based sector). The reason is that the explicit knowledge-based sector is more global. The T-test result for the difference in FVA between the electrical and other sectors can be found in the Appendix F.

Meanwhile, the square term of FVA in the electrical sector is relatively small than the others in Tables 5-1 and 5-2. Furthermore, in Table 5-1, the value of the dummy of the FVA square term and the FVA square term are lowest in the electrical sector. These results inform that the marginal effect of GVC on upgradation is relatively small in the electrical sector.

Table 5-2: Fixed-effect Model (WIOD) Non-linear Models

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -6.062*** | -8.847*** | -14.07*** | -12.14*** | -10.20*** | -14.71*** | -12.56*** |
| | (-5.61) | (-5.87) | (-10.62) | (-12.33) | (-6.86) | (-11.60) | (-13.02) |
| FVA Square | 5.931*** | 8.957*** | 15.19*** | 12.88*** | 10.40*** | 15.76*** | 13.31*** |
| | (5.60) | (4.89) | (9.96) | (11.17) | (5.62) | (10.53) | (11.57) |
| Dummy*FVA | | | | | 4.792** | 9.482*** | 7.347*** |
| | | | | | (2.82) | (5.95) | (5.51) |
| Dummy*FVA_sq | | | | | -4.878* | -10.47*** | -7.994*** |
| | | | | | (-2.38) | (-5.79) | (-5.33) |
| Dummy | | | | | 0 | 0 | 0 |
| | | | | | (.) | (.) | (.) |
| PL capital stock | 1.100*** | 0.251* | 0.696*** | 0.593*** | 0.781*** | 0.892*** | 0.765*** |
| | (11.73) | (2.42) | (8.54) | (9.56) | (11.30) | (14.76) | (14.84) |
| Employee (log) | -0.115 | -0.859*** | 0.0772 | -0.259** | -0.326*** | -0.0820 | -0.218*** |
| | (-0.92) | (-6.54) | (0.69) | (-3.28) | (-3.82) | (-1.01) | (-3.33) |
| Real GDP (log) | 0.975*** | 1.075*** | 1.035*** | 1.039*** | 0.961*** | 1.020*** | 0.997*** |
| | (4.89) | (5.92) | (5.25) | (7.81) | (7.14) | (7.31) | (9.04) |
| High-skilled labor | 0.0308*** | 0.00961 | 0.0130* | 0.0119** | 0.0191*** | 0.0228*** | 0.0181*** |
| | (5.15) | (1.78) | (2.56) | (3.20) | (4.71) | (5.97) | (5.77) |
| Export rate | -0.176 | -0.721*** | -0.620** | -0.572*** | -0.525*** | -0.439** | -0.513*** |
| | (-0.79) | (-3.61) | (-2.75) | (-3.84) | (-3.49) | (-2.79) | (-4.16) |
| Constant | -13.21*** | -0.634 | -8.399** | -6.195*** | -7.852*** | -10.69*** | -8.228*** |
| | (-5.41) | (-0.25) | (-3.20) | (-3.47) | (-4.50) | (-5.95) | (-5.70) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Observations | 570 | 570 | 570 | 1140 | 1140 | 1140 | 1710 |
| r2 | 0.543 | 0.541 | 0.451 | 0.475 | 0.515 | 0.485 | 0.486 |
| Turning point (E) | 0.51 | | | | 0.49 | 0.49 | 0.49 |
| Turning point (O) | | 0.49 | 0.46 | 0.47 | 0.49 | 0.47 | 0.47 |

*Notes: t* statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Turning point (E) indicates the turning point in electrical sector. Turning point (O) respects the turning point in other sectors excluding electrical sector. Model 1 reports results in the electric sector; Model 2 reports results in the transport sector; Model 3 reports average results in the machinery sector; Model 4 reports average results in the machinery and transport sector; Model 5 reports results in both the electric and transport sector with dummy variables; Model 6 reports results in both the electrical and machinery sector with dummy variables; Model 7 reports results in both the electrical and the average results in the machinery and transport sector with dummy variables.

Table 5-3: Sectoral Difference (WIOD, GMM) Non-linear Models

| | (1)<br>Electric | (2)<br>Machinery | (3)<br>Transport | (4)<br>Machinery & Transport | (5)<br>Electric vs Machinery | (6)<br>Electric vs Transport | (7)<br>Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -6.477*** | -15.45*** | -9.548*** | -9.103*** | -44.22*** | 40.23* | 12.91 |
| | (-10.59) | (-5.70) | (-6.84) | (-14.59) | (-5.25) | (2.02) | (1.14) |
| FVA Square | 4.911*** | 22.24*** | 15.59*** | 10.52*** | 63.37*** | -28.05 | 4.474 |
| | (8.21) | (6.42) | (8.55) | (12.42) | (5.17) | (-1.39) | (0.30) |
| Dummy*FVA | | | | | 17.77 | -84.25** | -66.52* |
| | | | | | (1.42) | (-2.65) | (-2.55) |
| Dummy*FVA_sq | | | | | -47.28** | 61.40* | 35.58 |
| | | | | | (-2.90) | (1.96) | (1.27) |
| Dummy | | | | | -0.630 | 36.09*** | 16.04 |
| | | | | | (-0.19) | (3.63) | (1.90) |
| PL capital stock | 0.894*** | 1.296*** | 0.413** | 0.443*** | 1.414*** | 0.163 | 1.414*** |
| | (19.11) | (8.65) | (3.12) | (11.45) | (9.65) | (0.44) | (3.88) |
| Employee (log) | -0.791*** | 0.662*** | -0.220 | -0.623*** | -0.0611 | 0.150 | 1.380** |
| | (-8.59) | (4.53) | (-1.42) | (-11.12) | (-0.29) | (0.33) | (2.93) |
| Real GDP (log) | -0.246** | -0.743*** | -1.427*** | -0.499*** | 0.213 | -0.515 | -1.766*** |
| | (-2.82) | (-4.43) | (-5.43) | (-9.29) | (1.24) | (-0.94) | (-3.60) |
| High-skilled labor | 0.0413*** | 0.0504*** | 0.0892*** | 0.0704*** | 0.0362*** | 0.0443** | 0.0344* |
| | (8.82) | (5.87) | (17.21) | (29.65) | (4.14) | (2.61) | (2.20) |
| Export rate | 0.733*** | -3.231*** | -0.133 | 1.960*** | 0.217 | 1.057 | 0.449 |
| | (5.66) | (-9.84) | (-1.21) | (19.62) | (0.58) | (1.55) | (0.56) |
| Constant | 7.147*** | 4.643*** | 23.96*** | 13.47*** | -1.646 | -4.481 | 5.494 |
| | (10.58) | (5.56) | (13.16) | (33.61) | (-0.77) | (-0.70) | (1.18) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Observations | 570 | 570 | 570 | 1140 | 1140 | 1140 | 1710 |
| AR_2_test | 0.451 | 0.615 | 0.418 | 0.592 | 0.899 | 0.178 | 0.128 |
| Hansen_test | 0.363 | 0.405 | 0.474 | 0.170 | 0.151 | 0.949 | 0.356 |
| Turning point (E) | 0.66 | | | | | | |
| Turning point (O) | | 0.34 | 0.31 | 0.43 | 0.35 | | |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$; P-values are presented for AR (2) and Hansen tests.

Turning point (E) indicates the turning point in the electrical sector. Turning point (O) respects the turning point in other sectors excluding electrical sector. Model 1 reports results in the electric sector; Model 2 reports results in the transport sector; Model 3 reports average results in the machinery sector; Model 4 reports average results in the machinery and transport sector; Model 5 reports results in both the electric and transport sector with dummy variables; Model 6 reports results in both the electrical and machinery sector with dummy variables; Model 7 reports results in both the electrical and the average results in the machinery and transport sector with dummy variables.

## 5.6. Conclusions

This research has found the differences in sectoral GVCs in different SISs. Each sector has a different knowledge base, which could be more explicit or more tacit. The explicit knowledge-based sectors join GVC via outsourcing, and the tacit knowledge-based sector integrate into GVC via FDI. Hence, this research compares and empirically analyzes the two kinds of sectoral GVCs in different innovation systems.

The robust and significant results estimated by fixed-effect and system GMM show two main findings. The first finding is that the explicit knowledge-based sector is more open than the tacit knowledge-based sector. The second finding states that the marginal effect of the global value chain on productivity is smaller in the explicit knowledge-based sector and bigger in the tacit knowledge-based sector. This research highlights the differences in sectoral GVCs, emphasizing the role of knowledge in different innovation systems. The results of this research suggest industry policymakers should consider the characteristic of each sectoral GVC.

This research has some limitations. First, this research examines the differences between manufacturing sectors, but not the service sectors. Obviously, knowledge is different in each sector, and thus the effects of GVC in manufacturing and service sectors would be different. Second, only one GVC participation indicator is used in this research. There are various GVC participation indicators. This study selected only one backward linkage indicator to indicate GVC participation. It would be interesting to analyze the difference in the effects of GVC participation in different innovation systems. All the limitations can be researched in the future.

# Chapter 6. Conclusion and Discussions

This research has investigated the actual effect of GVCs on economic growth and sectoral upgradation. The empirical analyses confirm the U-shaped (not the whole N-shaped pattern) hypothesis between the share of FVA in gross exports and economic growth and between the share of FVA in gross exports and sectoral upgradation in the upper-middle- and high- income economies. The N-shaped hypothesis states that an increased participation in GVC is helpful for facilitating explicit learning in the initial stage of growth, less foreign-dominated GVC is helpful for facilitating functional upgradation in the middle stage of growth, and an increased GVC participation benefits latecomers when they intend to seek benefits in a higher stage of development after building their own local value chain. The U-shaped (not the whole N-shaped pattern) hypothesis emphasizes the importance of building own local value chain.

In chapter 1, the motivation and objectives of this study have been described. GVCs have been identified as an important determinant in development studies. However, previous studies mostly focused on the linear relationship between GVCs and economic growth or industrial upgrading. This study attempts to identify the actual effects of GVC on economic growth and sectoral upgradation with a non-linear approach.

In chapter 3, the study examines the U-shaped (not the whole N-shaped pattern) hypothesis between the share of FVA in gross exports and economic growth in the upper-middle- and high-income economies by using systematical empirical analyses, including pooled OLS, fixed-effect, system GMM, and 3SLS estimations. The empirical results from our models show that the square of FVA term exerts a significant positive effect on economic growth. This finding shows that the actual effect of GVC on economic growth could be a U-shaped (parts of the N shape) and non-linear in the upper-middle- and high-income economies.

In chapter 4, the research examines the U-shape (not the whole N-shaped pattern) hypothesis between the share of FVA in gross exports and sectoral labor productivity in nine manufacturing sectors in the upper-middle- and high- income economies, by using systematical empirical analyses, including pooled OLS, fixed-effect, and system GMM estimations. The empirical results, based on the use of WIOD and UNIDO databases, of our models show that the square of FVA term exerts a significant positive effect on economic growth. This finding shows that the actual effect of GVC on economic growth could be U-shaped (parts of the N shape) and non-linear in most manufacturing sectors in the upper-middle- and high-income economies.

In chapter 5, I attempt to find the differences in sectoral GVCs through different SISs. The research finds that sectoral GVCs could be different in the explicit knowledge-based sector and tacit knowledge-based sector, by using case studies on the Apple and GM groups. Empirical results estimated by fixed-effect and system GMM confirm that the explicit knowledge-based sector is more open than the tacit knowledge-based sector, and that the marginal effect of the global value chain on productivity is smaller in the explicit knowledge-based sector, and it is bigger in the tacit knowledge-based sector.

The contributions of this study are as follows. First, this study has confirmed the U-shaped (not the whole N-shaped pattern) hypothesis between the share of FVA in gross exports and economic growth in only upper-middle- and high-income economies. The whole N-shaped pattern hypothesis expressing that, in the initial stage of growth of a latecomer, an increased participation in the GVC will facilitate the acquisition of foreign knowledge and production skills; functional upgradation, in the middle-income stage, would require latecomers separate from and operate independently of existing foreign-dominated GVCs; latecomer firms and economies might have to seek reintegration into the GVC after establishing their own local value chains (Lee et al., 2018). This study proposes that the U-shaped pattern of GVC participation could be more effective for emerging economies, based on systemic empirical analyses at the national level, while previous research focused on the linear relationship between GVC and economic growth (UNCTAD, 2013; WTO, 2019; Fagerberg et al., 2018). The mechanism would be that less foreign-dominated GVC would be crucial for facilitating functional upgradation in the middle stage of growth, and an increased participation in GVC would be effective in a higher stage of development when latecomers intend to seek benefits after building own local value chain in high-and middle-income economies.

Second, this research also examined the U-shaped (not the whole N-shaped pattern) hypothesis between the share of FVA in gross exports and the sectoral productivity in nine manufacturing sectors in upper-middle- and high-income economies. The previous industrial studies mostly focus on the linear and positive relationship between GVCs and sectoral productivity (Formai and Caffarelli, 2015; Kordalska et al., 2016; Neagu et al., 2017). The empirical results on most manufacturing sectors in this research verify the U-shaped hypothesis at the sectoral level.

Third, this research demonstrates that the sectoral GVCs could be different in different SISs, by using the case study and the empirical analysis. In the explicit knowledge-based sector, firms integrate into GVC via outsourcing; in the tacit knowledge-based sector, firms integrate into GVC via the FDI route. Thus, the explicit knowledge-based sector is more open than the tacit knowledge-based sector, and the marginal effect of the GVC on productivity is smaller in the explicit knowledge-based sector and bigger in the tacit knowledge-based sector.

The study has limitations. First, this study lacks discussion on GVC effects in low-income economies. This can be attributed to the unavailability of low-income data in the existing database. Second, the sectoral level of empirical research in this study only discussed the manufacturing sectors but not the service sectors. Third, only one backward GVC indicator is selected to conduct the empirical analysis. Fourth, this research focused on the national- and sectoral-level analyses and lacked firm-level empirical analysis

The limitations of this study present directions for future research. In the future, I will attempt to investigate empirically how to engage in the GVCs and benefit from them in the initial growth stage. Moreover, the service sector is an important part of economic growth, and service-based GVCs have also witnessed accelerated development. The effects of service sectors on economic growth should be an important research issue. Additionally, the forward linkage GVC indicator may influence economic growth and sectoral upgradation through another mechanism. The mechanism of forward linkage should be investigated in the future research. Finally, conducting a micro-qualitative research using this non-linear approach could be an interesting and important research issue.

# Appendix

## Appendix A

National level FVA can be calculated by input-output table base on Hummels, D., et al. (2001), as follows:

$$\mathrm{A^D X + Y^D = X} \rightarrow \quad X = (\mathrm{I} - A^D)^{-1} Y^D$$
$$\mathrm{A^M X + Y^M = M} \qquad \text{A-1}$$
$$FVA = \mu A^M (I - A^D)^{-1} E / E_T$$

- $FVA$: foreign value-added share of gross export
- A: direct input coefficients of domestic products
- Y: final demands for produced products
- X: gross output
- D: domestically produced
- M: imported products
- $E$ : exports
- $E_T$: total exports
- $\mu$: 1×n unit vector

Sectoral level FVA can be calculated by the input-output table as following:

$$\mathrm{A^D X + Y^D = X} \rightarrow \quad X = (\mathrm{I} - A^D)^{-1} Y^D$$
$$\mathrm{A^M X + Y^M = M} \qquad \text{A-2}$$
$$FVA = \mu A^M (I - A^D)^{-1}$$

- $FVA$: foreign value-added share of gross export
- A: direct input coefficients of domestic products
- Y: final demands for produced products
- X: gross output
- D: domestically produced
- M: imported products
- $\mu$: 1×n unit vector

## Appendix B

Table B-1: Economies List

| | | | | | | |
|---|---|---|---|---|---|---|
| Argentina | Chile | Estonia | Indonesia | Malaysia | Poland | **Sweden** |
| **Australia** | China | **Finland** | **Ireland** | **Malta** | **Portugal** | Slovak Republic |
| **Austria** | Chinese Taipei | **France** | **Israel** | Mexico | Romania | **Switzerland** |
| **Belgium** | Colombia | **Germany** | **Italy** | **Morocco** | Russian Federation | Thailand |
| Brazil | Costa Rica | **Greece** | **Japan** | **Netherlands** | **Saudi Arabia** | Tunisia |
| **Brunei Darussalam** | Croatia | **Hong Kong, China** | **Korea** | **New Zealand** | **Singapore** | Turkey |
| Bulgaria | **Cyprus** | Hungary | Latvia | **Norway** | **Slovenia** | **United Kingdom** |
| Cambodia | Czech Republic | **Iceland** | Lithuania | Peru | South Africa | **United States** |
| **Canada** | **Denmark** | India | **Luxembourg** | Philippines | **Spain** | Viet Nam |

# Appendix C

Table C-1: Descriptive Statistics for Chapter 3

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Per Capita GDP (log) | 252 | 9.81 | .841 | 7.038 | 11.347 |
| Per Capita GDP (log) in initial year | 252 | 9.763 | .851 | 7.067 | 11.366 |
| FVA | 252 | .252 | .109 | .037 | .573 |
| FVA Square | 252 | .075 | .061 | .001 | .329 |
| Population growth rate | 252 | .008 | .009 | -.014 | .03 |
| Investment per GDP | 252 | .233 | .047 | .113 | .422 |
| Year of total school (log) | 252 | 2.172 | .271 | 1.238 | 2.561 |
| Openness | 252 | .773 | .64 | .077 | 4.864 |
| FVA | 252 | .245 | .109 | .023 | .577 |
| Per Capita GDP (log) square | 252 | 96.94 | 15.902 | 49.537 | 128.758 |
| Inflow FDI | 249 | .065 | .179 | -.015 | 2.511 |
| Population(log) | 252 | 2.751 | 1.776 | -1.304 | 7.193 |
| Share of manufacture in export | 252 | .535 | .166 | .014 | .782 |

Table C-2: Descriptive Statistics for Chapter 4 (WIOD and OECD-TiVA)

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Per labor value added (log) | 5400 | 9.752 | 1.601 | 2.858 | 13.65 |
| FVA | 6120 | .32 | .128 | .043 | .843 |
| FVA square | 6120 | .119 | .093 | .002 | .711 |
| Per labor capital stock (log) | 5130 | 11.416 | 2.37 | 3.923 | 18.708 |
| Number of employee (log) | 6120 | 4.884 | 2 | -1.328 | 10.385 |
| Share of high skilled labor | 5369 | 20.157 | 9.704 | .757 | 62.549 |
| Real GDP (log) | 6120 | 12.93 | 1.715 | 8.755 | 16.563 |
| Rate of exports in outputs | 6120 | .376 | .216 | .004 | 1.081 |

Table C-3: Descriptive Statistics for Chapter 4 (UNIDO and OECD-TiVA)

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Per labor value added (log) | 5983 | 10.664 | .925 | 7.857 | 14.876 |
| FVA | 6120 | .32 | .128 | .043 | .843 |
| FVA square | 6120 | .119 | .093 | .002 | .711 |
| Per Labor GFCF (log) | 4747 | 8.908 | .895 | 2.062 | 13.623 |
| Number of employee (log) | 6069 | 4.606 | 1.856 | -3.65 | 9.734 |
| Share of high skilled labor | 5369 | .202 | .097 | .008 | .625 |
| Real GDP (log) | 6120 | 12.93 | 1.715 | 8.755 | 16.563 |
| Rate of exports in outputs | 6120 | .376 | .216 | .004 | 1.081 |

Table C-4: Descriptive Statistics for Chapter 5 (WIOD and OECD-TiVA)

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Per labor value added (log) | 1800 | 9.911 | 1.578 | 3.65 | 13.65 |
| FVA | 2040 | .365 | .132 | .057 | .843 |
| FVA square | 2040 | .15 | .108 | .003 | .711 |
| Per Labor GFCF (log) | 1710 | 11.329 | 2.324 | 5.407 | 18.708 |
| Number of employee (log) | 2040 | 4.592 | 2.062 | -1.328 | 9.814 |
| Share of high skilled labor | 2040 | 12.93 | 1.715 | 8.755 | 16.563 |
| Real GDP (log) | 1800 | 20.964 | 10.396 | 3.374 | 62.549 |
| Rate of exports in outputs | 2040 | .483 | .204 | .036 | .973 |

Table C-5: Matrix of Correlations for Chapter 3

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Per Capita GDP (log) | 1.000 | | | | | | | | | | | | |
| (2) Per Capita GDP (log) in initial year | 0.998 | 1.000 | | | | | | | | | | | |
| (3) FVA | 0.050 | 0.050 | 1.000 | | | | | | | | | | |
| (4) FVA Square | 0.069 | 0.068 | 0.969 | 1.000 | | | | | | | | | |
| (5) Population growth rate | -0.116 | -0.116 | -0.151 | -0.081 | 1.000 | | | | | | | | |
| (6) Investment per GDP | -0.092 | -0.102 | 0.287 | 0.237 | -0.073 | 1.000 | | | | | | | |
| (7) Year of total school (log) | 0.753 | 0.756 | 0.169 | 0.162 | -0.370 | -0.036 | 1.000 | | | | | | |
| (8) Openness | 0.495 | 0.488 | 0.431 | 0.435 | 0.057 | 0.156 | 0.297 | 1.000 | | | | | |
| (9) FVA | 0.070 | 0.069 | 0.988 | 0.959 | -0.147 | 0.291 | 0.185 | 0.446 | 1.000 | | | | |
| (10) Per Capita GDP (log) square | 0.998 | 0.997 | 0.051 | 0.072 | -0.096 | -0.096 | 0.739 | 0.504 | 0.070 | 1.000 | | | |
| (11) Inflow FDI | 0.132 | 0.133 | 0.275 | 0.318 | 0.034 | -0.038 | 0.077 | 0.281 | 0.277 | 0.137 | 1.000 | | |
| (12) Population(log) | -0.433 | -0.431 | -0.334 | -0.347 | 0.094 | 0.140 | -0.345 | -0.461 | -0.333 | -0.434 | -0.283 | 1.000 | |
| (13) Share of manufacture in export | -0.106 | -0.100 | 0.362 | 0.274 | -0.267 | 0.232 | 0.127 | -0.112 | 0.344 | -0.122 | -0.163 | 0.356 | 1.000 |

Table C-6: Matrix of Correlations for Chapter 4 (WIOD and OECD-TiVA)

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) Per labor value added (log) | 1.000 | | | | | | | |
| (2) FVA | 0.003 | 1.000 | | | | | | |
| (3) FVA square | 0.004 | 0.967 | 1.000 | | | | | |
| (4) Per labor capital stock (log) | 0.422 | -0.102 | -0.078 | 1.000 | | | | |
| (5) Number of employee (log) | -0.192 | -0.506 | -0.448 | 0.240 | 1.000 | | | |
| (6) Real GDP (log) | 0.086 | -0.537 | -0.485 | 0.320 | 0.879 | 1.000 | | |
| (7) Share of high skilled labor | 0.442 | -0.114 | -0.108 | 0.266 | 0.008 | 0.177 | 1.000 | |
| (8) Rate of exports in outputs | 0.085 | 0.627 | 0.592 | -0.139 | -0.525 | -0.490 | -0.079 | 1.000 |

Table C-7: Matrix of Correlations for Chapter 4 (UNIDO and OECD-TiVA)

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) Per labor value added (log) | 1.000 | | | | | | | |
| (2) FVA | -0.118 | 1.000 | | | | | | |
| (3) FVA square | -0.096 | 0.969 | 1.000 | | | | | |
| (4) Per Labor GFCF (log) | 0.620 | 0.008 | 0.018 | 1.000 | | | | |
| (5) Number of employee (log) | 0.111 | -0.555 | -0.499 | 0.178 | 1.000 | | | |
| (6) Real GDP (log) | 0.334 | -0.573 | -0.520 | 0.224 | 0.870 | 1.000 | | |
| (7) Share of high skilled labor | 0.405 | -0.110 | -0.116 | 0.155 | 0.159 | 0.295 | 1.000 | |
| (8) Rate of exports in outputs | -0.069 | 0.661 | 0.628 | -0.084 | -0.497 | -0.477 | -0.126 | 1.000 |

Table C-8: Matrix of Correlations for Chapter 5 (WIOD and OECD-TiVA)

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) Per labor value added (log) | 1.000 | | | | | | | |
| (2) FVA | -0.061 | 1.000 | | | | | | |
| (3) FVA square | -0.038 | 0.973 | 1.000 | | | | | |
| (4) Per labor capital stock (log) | 0.498 | -0.114 | -0.071 | 1.000 | | | | |
| (5) Number of employee (log) | -0.055 | -0.433 | -0.371 | 0.327 | 1.000 | | | |
| (6) Real GDP (log) | 0.147 | -0.537 | -0.484 | 0.371 | 0.912 | 1.000 | | |
| (7) Share of high skilled labor | 0.406 | -0.266 | -0.242 | 0.312 | 0.170 | 0.285 | 1.000 | |
| (8) Rate of exports in outputs | 0.191 | 0.677 | 0.631 | -0.092 | -0.544 | -0.572 | -0.145 | 1.000 |

## Appendix D

Table D-1: Main Industry Datasets

| | UNIDO | WIOD-SEA (version 2014) | OECD-TiVA (version 2016) |
|---|---|---|---|
| Country | more than 63 | 40 | 63 |
| Time(year) | 1963-2016 with gaps | 1995-2009 | 1995-2011 |
| Number of employees | * | O | X |
| Output | * | O | O |
| value-added | * | O | O |
| Gross fixed capital formation | * | O | X |
| Real fixed capital stock | X | O | X |
| Labor skill (high mid low) | X | * | X |
| Export | X | X | O |
| Share of FVA | X | X | O |
| Real price calculates | need GDP deflator (2010 constant) | O (1995 constant) | need GDP deflator (2010 constant) |
| Unit | USD | local currency | USD |

X: No data available *: Missing observation O: Available

# Appendix E

The linear regression results with total sample in fixed-effect models and system GMM models are reported in Table E-1 and Table E-2. Moreover, the sample has been separated into less GVC group (FVA<0.32) and more GVC group (FVA>=0.32) to ran linear regressions for robust results. The fixed-effect results of less GVC group are reported in Table E-3 and system GMM result of less GVC group can be found in Table E-4. Table E-5 and Table E-6 show the results of more GVC group by using fixed-effect estimations and system GMM estimations.

As shown in Table E-1 and Table E-2, using linear regression to estimate the total sample cannot obtain robust results of FVA. The linear regression significant results show that the effects of GVC are negative in less GVC group, and are positive in more GVC group. The estimated slops in the electrical sector in each model are flatter than slops in other sectors. Therefore, the marginal effects of the electric sector are smaller than others on upgrading. The openness of each sector is difficult to check by using linear regressions. However, the mean value of the electric sector is not lower than the others. The electric sector could be more open than others. Also, the dummy term results in model 6 of Table E-2, Table E-4 and Table E-6 are positive and significant. The robust dummy results demonstrate that the productivity of the electric sector could be higher than the transport sector. In Table E-3, on significant results are found in FVA term and FVA dummy term, however, the symbol of each sector slope is positive.

Table E-2: Sectoral Difference (WIOD, FE) Linear Models

| | (1)<br>Electric | (2)<br>Machinery | (3)<br>Transport | (4)<br>Machinery & Transport | (5)<br>Electric vs Machinery | (6)<br>Electric vs Transport | (7)<br>Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -0.345 | -1.749*** | -1.569*** | -1.635*** | -2.055*** | -1.804*** | -1.791*** |
| | (-0.94) | (-4.15) | (-3.40) | (-5.28) | (-4.86) | (-4.56) | (-6.10) |
| Dummy*FVA | | | | | 2.056*** | 1.708*** | 1.803*** |
| | | | | | (4.03) | (3.49) | (4.33) |
| Dummy | | | | | 0 | 0 | 0 |
| | | | | | (.) | (.) | (.) |
| PL capital stock | 1.120*** | 0.255* | 0.689*** | 0.603*** | 0.800*** | 0.892*** | 0.776*** |
| | (11.61) | (2.40) | (7.74) | (9.19) | (11.29) | (13.90) | (14.37) |
| Employee (log) | 0.0144 | -0.882*** | 0.0974 | -0.235** | -0.273** | -0.0288 | -0.169* |
| | (0.11) | (-6.58) | (0.79) | (-2.82) | (-3.12) | (-0.34) | (-2.48) |
| Real GDP (log) | 0.885*** | 1.182*** | 1.155*** | 1.177*** | 0.998*** | 1.045*** | 1.070*** |
| | (4.32) | (6.41) | (5.37) | (8.40) | (7.23) | (7.06) | (9.27) |
| High-skilled labor | 0.0304*** | 0.00641 | 0.00453 | 0.00544 | 0.0166*** | 0.0172*** | 0.0131*** |
| | (4.93) | (1.17) | (0.83) | (1.40) | (3.98) | (4.28) | (4.01) |
| Export rate | -0.252 | -0.877*** | -0.656** | -0.687*** | -0.644*** | -0.491** | -0.616*** |
| | (-1.11) | (-4.35) | (-2.67) | (-4.38) | (-4.21) | (-2.94) | (-4.77) |
| Constant | -13.98*** | -3.008 | -12.01*** | -9.843*** | -9.903*** | -12.78*** | -10.96*** |
| | (-5.57) | (-1.20) | (-4.23) | (-5.30) | (-5.61) | (-6.73) | (-7.33) |
| Observations | 570 | 570 | 570 | 1140 | 1140 | 1140 | 1710 |
| r2 | 0.515 | 0.520 | 0.344 | 0.412 | 0.487 | 0.418 | 0.435 |
| Slope (E) | - | | | | 0.001*** | -0.096*** | 0.012*** |
| Slope (O) | | -1.749*** | -1.569*** | -1.635*** | -2.055*** | -1.804*** | -1.791*** |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

Slope (E) indicates the slope in electrical sector. Slope (O) respects the slope in other sectors excluding electrical sector.

Table E-3: Sectoral Difference (WIOD, GMM) Linear Models

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -2.105$^{***}$ | 0.904$^{**}$ | 5.095$^{***}$ | -1.462$^{***}$ | 2.514$^{***}$ | 15.77$^{***}$ | 10.15$^{***}$ |
| | (-12.04) | (3.18) | (17.91) | (-10.36) | (3.43) | (3.98) | (4.11) |
| Dummy*FVA | | | | | -16.48$^{***}$ | -29.20$^{***}$ | -33.09$^{***}$ |
| | | | | | (-10.13) | (-5.06) | (-4.62) |
| Dummy | | | | | 6.481$^{***}$ | 24.13$^{***}$ | 19.18$^{***}$ |
| | | | | | (3.95) | (3.43) | (3.95) |
| PL capital stock | 0.885$^{***}$ | 1.422$^{***}$ | 0.499$^{***}$ | 0.571$^{***}$ | 1.268$^{***}$ | 0.245 | 0.594$^{*}$ |
| | (8.16) | (12.08) | (6.17) | (14.84) | (9.45) | (0.68) | (2.20) |
| Employee (log) | -0.861$^{***}$ | 0.698$^{***}$ | -0.142 | -0.549$^{***}$ | 0.130 | 0.0258 | -0.0731 |
| | (-10.58) | (7.58) | (-1.40) | (-8.68) | (0.92) | (0.05) | (-0.20) |
| Real GDP (log) | -0.195 | -0.811$^{***}$ | -1.576$^{***}$ | -0.479$^{***}$ | 0.184 | -0.749 | -0.126 |
| | (-1.92) | (-5.43) | (-12.50) | (-11.68) | (1.41) | (-1.37) | (-0.27) |
| High-skilled labor | 0.0344$^{***}$ | 0.0317$^{***}$ | 0.0646$^{***}$ | 0.0596$^{***}$ | 0.0195$^{***}$ | 0.0493$^{***}$ | 0.0322$^{**}$ |
| | (9.58) | (9.22) | (10.85) | (28.49) | (5.18) | (3.30) | (2.72) |
| Export rate | 0.545$^{***}$ | -4.135$^{***}$ | -0.934$^{***}$ | 1.495$^{***}$ | -0.495$^{**}$ | 1.249 | 1.172 |
| | (4.76) | (-15.53) | (-6.62) | (22.31) | (-2.80) | (1.78) | (1.58) |
| Constant | 6.356$^{***}$ | 1.894 | 22.41$^{***}$ | 10.62$^{***}$ | -8.565$^{***}$ | 3.056 | -1.545 |
| | (13.05) | (1.91) | (21.05) | (22.09) | (-10.17) | (0.55) | (-0.41) |
| Observations | 570 | 570 | 570 | 1140 | 1140 | 1140 | 1710 |
| AR_2_test | 0.423 | 0.400 | 0.269 | 0.401 | 0.565 | 0.0566 | 0.399 |
| Hansen_test | 0.425 | 0.483 | 0.521 | 0.192 | 0.0555 | 0.821 | 0.705 |
| Slope (E) | -2.105$^{***}$ | | | | -13.966$^{***}$ | -13.43$^{***}$ | -22.94$^{***}$ |
| Slope (O) | | 0.904$^{**}$ | 5.095$^{***}$ | -1.462$^{***}$ | 2.514$^{***}$ | 15.77$^{***}$ | 10.15$^{***}$ |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$; P-values are presented for AR (2) and Hansen tests. Slope (E) indicates the slope in electrical sector. Slope (O) respects the slope in other sectors excluding electrical sector.

Table E-4: Sectoral Difference (WIOD, FE) Linear Models Less GVC

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -2.364* | -4.444*** | -3.728** | -4.199*** | -4.685*** | -5.313*** | -4.650*** |
| | (-2.48) | (-3.81) | (-2.83) | (-4.92) | (-4.97) | (-5.23) | (-6.32) |
| Dummy*FVA | | | | | 3.207** | 4.729*** | 3.836*** |
| | | | | | (2.91) | (3.82) | (3.78) |
| Dummy | | | | | 0 | 0 | 0 |
| | | | | | (.) | (.) | (.) |
| PL capital stock | 1.421*** | 0.383 | 1.114*** | 0.687*** | 1.008*** | 1.130*** | 0.933*** |
| | (8.21) | (1.70) | (6.06) | (5.44) | (7.34) | (10.19) | (9.55) |
| Employee (log) | -0.473* | -0.523* | -0.447 | -0.527*** | -0.367* | -0.552*** | -0.509*** |
| | (-2.47) | (-2.27) | (-1.89) | (-3.83) | (-2.53) | (-3.96) | (-4.63) |
| Real GDP (log) | 0.375 | 0.538* | 0.0633 | 0.373 | 0.248 | 0.161 | 0.233 |
| | (1.45) | (2.03) | (0.19) | (1.79) | (1.35) | (0.78) | (1.45) |
| High-skilled labor | 0.0220* | 0.0254** | 0.0292*** | 0.0243*** | 0.0299*** | 0.0310*** | 0.0286*** |
| | (2.04) | (2.97) | (3.84) | (4.56) | (4.68) | (5.91) | (6.46) |
| Export rate | -1.607*** | -2.379*** | -2.933*** | -2.560*** | -1.944*** | -2.012*** | -2.128*** |
| | (-5.78) | (-6.13) | (-5.53) | (-8.20) | (-8.37) | (-7.72) | (-9.89) |
| Constant | -7.786 | 2.828 | -0.164 | 1.505 | -1.583 | -1.262 | 0.189 |
| | (-1.86) | (0.58) | (-0.03) | (0.48) | (-0.50) | (-0.42) | (0.08) |
| Observations | 226 | 273 | 206 | 479 | 499 | 432 | 705 |
| r2 | 0.680 | 0.524 | 0.535 | 0.504 | 0.566 | 0.586 | 0.542 |
| Slope (E) | -2.364* | | | | -1.478*** | -0.584*** | -0.814*** |
| Slope (O) | | -4.444*** | -3.728** | -4.199*** | -4.685*** | -5.313*** | -4.650*** |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$. Slope (E) indicates the slope in electrical sector. Slope (O) respects the slope in other sectors excluding electrical sector.

Table E-5: Sectoral Difference (WIOD, GMM) Linear Models Less GVC

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | -1.014 | -8.898*** | -11.15*** | -10.43*** | -6.027 | 14.36 | 5.218 |
| | (-1.09) | (-13.10) | (-7.51) | (-21.00) | (-0.44) | (1.33) | (0.81) |
| Dummy*FVA | | | | | -4.757 | -52.94** | -42.53* |
| | | | | | (-0.19) | (-2.78) | (-2.37) |
| Dummy | | | | | 2.764 | 18.22*** | 15.52** |
| | | | | | (0.39) | (3.45) | (2.81) |
| PL capital stock | 0.465** | 0.372*** | 0.987*** | 0.647*** | 0.374 | 0.489* | 0.407 |
| | (3.06) | (4.81) | (3.68) | (10.41) | (1.48) | (2.01) | (1.79) |
| Employee (log) | 0.719*** | -1.189*** | -0.758 | -0.555** | -0.298 | -0.399 | -0.467 |
| | (4.65) | (-5.78) | (-1.59) | (-2.97) | (-0.47) | (-0.33) | (-0.61) |
| Real GDP (log) | -1.489*** | 1.099*** | 0.212 | 0.00720 | -0.522 | -0.0953 | -0.0765 |
| | (-5.51) | (5.22) | (0.40) | (0.04) | (-0.78) | (-0.08) | (-0.08) |
| High-skilled labor | 0.131*** | 0.0176 | 0.00814 | 0.0520*** | 0.103*** | 0.0375 | 0.0531 |
| | (5.76) | (1.92) | (0.82) | (6.33) | (3.32) | (0.92) | (1.43) |
| Export rate | -1.959** | 0.698 | -2.795*** | -1.674*** | -0.238 | -0.379 | 1.445 |
| | (-2.78) | (1.33) | (-4.79) | (-6.07) | (-0.07) | (-0.18) | (0.55) |
| Constant | 19.02*** | -1.239 | 2.882 | 7.366*** | 13.08** | 1.349 | 4.158 |
| | (6.96) | (-1.01) | (1.59) | (6.26) | (2.58) | (0.15) | (0.51) |
| Observations | 226 | 273 | 206 | 479 | 499 | 432 | 705 |
| AR_2_test | 0.488 | 0.119 | 0.608 | 0.445 | 0.657 | 0.724 | 0.564 |
| Hansen_test | 0.906 | 0.929 | 0.743 | 0.158 | 0.234 | 0.845 | 0.422 |
| Slope (E) | - | | | | - | - | - |
| Slope (O) | | -8.898*** | -11.15*** | -6.418*** | - | + | + |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$; P-values are presented for AR (2) and Hansen tests. Slope (E) indicates the slope in electrical sector. Slope (O) respects the slope in other sectors excluding electrical sector.

Table E-6: Sectoral Difference (WIOD, FE) Linear Models More GVC

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | 0.582 | 0.751 | 0.0962 | 0.479 | 0.652 | 0.0113 | 0.365 |
| | (1.39) | (1.89) | (0.23) | (1.59) | (1.38) | (0.03) | (1.19) |
| Dummy*FVA | | | | | 0.296 | 0.737 | 0.490 |
| | | | | | (0.52) | (1.46) | (1.14) |
| Dummy | | | | | 0 | 0 | 0 |
| | | | | | (.) | (.) | (.) |
| PL capital stock | 0.813*** | 0.0995 | 0.705*** | 0.604*** | 0.564*** | 0.775*** | 0.674*** |
| | (7.06) | (0.99) | (8.82) | (9.49) | (7.26) | (12.00) | (12.25) |
| Employee (log) | 0.0264 | -1.268*** | 0.458*** | -0.0365 | -0.316** | 0.277** | 0.0133 |
| | (0.17) | (-8.65) | (4.29) | (-0.42) | (-3.08) | (3.17) | (0.18) |
| Real GDP (log) | 1.486*** | 1.643*** | 1.532*** | 1.597*** | 1.630*** | 1.489*** | 1.564*** |
| | (5.19) | (7.28) | (6.64) | (9.47) | (8.67) | (8.31) | (10.78) |
| High-skilled labor | 0.0213** | 0.00339 | 0.0149* | 0.00605 | 0.00960 | 0.0179*** | 0.0109** |
| | (2.79) | (0.51) | (2.18) | (1.20) | (1.82) | (3.52) | (2.60) |
| Export rate | 0.366 | -0.337 | -0.180 | -0.190 | -0.131 | -0.0661 | -0.137 |
| | (1.07) | (-1.81) | (-0.88) | (-1.30) | (-0.73) | (-0.38) | (-1.02) |
| Constant | -17.72*** | -6.364* | -18.20*** | -16.00*** | -15.01*** | -17.99*** | -16.66*** |
| | (-5.31) | (-2.37) | (-6.20) | (-7.73) | (-6.90) | (-8.20) | (-9.53) |
| Observations | 344 | 297 | 364 | 661 | 641 | 708 | 1005 |
| r2 | 0.589 | 0.724 | 0.542 | 0.565 | 0.602 | 0.558 | 0.566 |
| Slope (E) | + | | | | + | + | + |
| Slope (O) | | + | + | + | + | + | + |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$. Slope (E) indicates the slope in electrical sector. Slope (O) respects the slope in other sectors excluding electrical sector.

Table E-7: Sectoral Difference (WIOD, GMM) Linear Models More GVC

| | (1) Electric | (2) Machinery | (3) Transport | (4) Machinery & Transport | (5) Electric vs Machinery | (6) Electric vs Transport | (7) Electric vs Machinery & Transport |
|---|---|---|---|---|---|---|---|
| FVA | 0.921** | 3.443*** | 2.586*** | 4.185*** | 4.232** | 9.999*** | 6.743** |
| | (3.19) | (4.84) | (7.12) | (8.65) | (2.81) | (5.32) | (2.67) |
| Dummy*FVA | | | | | -1.185 | -8.054** | -7.466 |
| | | | | | (-0.54) | (-3.20) | (-1.06) |
| Dummy | | | | | 1.139 | 2.057 | 2.254 |
| | | | | | (1.16) | (1.93) | (0.60) |
| PL capital stock | 0.818*** | 0.494*** | 0.742*** | 0.711*** | 0.883*** | 0.646*** | 0.866*** |
| | (16.47) | (3.81) | (19.59) | (6.39) | (7.50) | (5.17) | (3.64) |
| Employee (log) | -0.251* | -0.218 | -0.209 | 0.294 | -0.429* | -0.325 | -0.331 |
| | (-2.36) | (-1.34) | (-0.91) | (1.33) | (-2.34) | (-1.30) | (-0.55) |
| Real GDP (log) | -0.295*** | 0.0724 | 0.0294 | -0.524* | 0.0560 | 0.0485 | 0.0804 |
| | (-3.91) | (0.29) | (0.14) | (-2.13) | (0.30) | (0.16) | (0.15) |
| High-skilled labor | 0.0679*** | 0.0811*** | -0.0131** | 0.0487*** | 0.0522*** | 0.0175 | 0.0248 |
| | (10.01) | (6.75) | (-3.21) | (5.73) | (3.78) | (1.95) | (0.74) |
| Export rate | -0.908** | -4.779*** | -0.710*** | -3.413*** | -4.986*** | -4.004*** | -5.287* |
| | (-3.22) | (-10.72) | (-7.43) | (-10.67) | (-10.89) | (-11.65) | (-2.51) |
| Constant | 4.223*** | 3.672 | 1.508 | 6.365*** | 0.686 | 1.733 | 0.504 |
| | (5.35) | (1.92) | (0.89) | (3.69) | (0.53) | (0.76) | (0.13) |
| Observations | 344 | 297 | 364 | 661 | 641 | 708 | 1005 |
| AR_2_test | 0.675 | 0.158 | 0.489 | 0.284 | 0.158 | 0.121 | 0.150 |
| Hansen_test | 0.883 | 0.921 | 0.787 | 0.257 | 0.211 | 0.433 | 0.281 |
| Slope (E) | 0.921** | | | | + | 1.945*** | - |
| Slope (O) | | 3.443*** | 2.586*** | 4.185*** | 4.232** | 9.999*** | 6.743*** |

*Notes:* $t$ statistics in parentheses; $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$; P-values are presented for AR (2) and Hansen tests. Slope (E) indicates the slope in electrical sector and Slope (O) respects the slope in other sectors excluding electrical sector.

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# 국문초록

## 글로벌 가치사슬 (GVCs), 업그레이딩 그리고 경제성장

마오주칭

경제학부 경제학전공

서울대학교 대학원

글로벌 가치사슬 (GVCs)는 중간재 무역의 증가와 함께 경제성장의 중요한 결정 요인이었다. 정보통신기술 (ICT) 혁명은 세계화에 새로운 물결을 가져왔다. 이러한 새로운 물결 속 후발 주자들은 글로벌 생산 네트워크를 통합할 기회를 얻게 된다. 생산과정이 국제적으로 분리되면서 후발주자에게 많은 생산단계가 옮겨지는 결과로 이어졌고 (Baldwin, 2016), 이들은 세계 경제에서 자신들의 위치를 개선하기 위해 노력한다. 이러한 과정을 GVC 업그레이드라 일컫는다. (Gereffi, 2015)

Humphrey 와 Schmitz (2002)는 공정, 제품, 기능 및 부문간 업그레이드 등의 네가지 유형을 제시한다. Pietrobelli 와 Rabellotti (2011)는 공정이나 제품 업그레이드는 일반적으로 일어나지만 기능적 업그레이드는 드물다고 지적했다. Lee 와 Mathews (2012)는 기능적, 부문간 업그레이드가 성공적인 캐치업 모델의 열쇠라고 강조한다. 다시 말해, 글로벌 가치사슬 (GVCs)는 자연스럽게 기능이 업그레이드 되지 않을 수 있으며, 후발 주자들은 중진국 함정의 경우인 저-부가가치 활동에 갇힐 수 있다. (Humphery 와 Schmitx, 2004; Lee 등 , 2018; Blazek, 2015).

대부분의 선행연구는 글로벌 가치사슬 (GVCs)과 경제성장의 선형관계 (UNCTAD, 2013; WTO, 2019; Fagerberg 등, 2018) 또는 글로벌 가치사슬과 생산성 사이의 정적 상관관계 및 선형관계 (Formai 와 Caffarelli, 2015; Kordalsak 등, 2016; Neagu 등, 2017)에 초점을 맞추었다. 최근, 한국과 브라질 내 회사들의 업그레이드 사례와 글로벌가치사슬 데이터를 조사해 성공적인 Catch-up 경제에 N 형태 패턴의 GVC 참여를 제안해온 Lee 외 (2018)에서 국가수준의 비선형 GVC 참여 패턴이 확인되어왔다. N 형태의 패턴은 많은 GCV 가 성장 초기단계에서는 외부로부터 학습에 도움이 되고, 성장 중간단계에서는 기능 업그레이드를 위하여 외국으로부터 지배가 덜한 GVC 가 요구되며, 더 많은 GVC 가 자체적인 지역 가치사슬을 구축한 후 더 높은 개발단계에서 이익을 효과적으로 추구하는 것들을 보여준다.

이 연구의 목적은 비선형 GVC 참여패턴이 국가 차원의 경제성장과 분야별 생산성 향상에 어떻게 작용하는지 와 작용 여부를 조사하는 것이다. 본 연구는 또한 서로 다른 분야별 혁신 시스템들 내 부문별 GVC 들간의 차이를 찾을 예정이다.

첫째, 본 논문은 국가 데이터 베이스 (Penn Word Table)와 무역 데이터 베이스 (TiVA)를 활용하여 중상위권 및 고소득층의 경제성장에 대한 실제 GVC 의 영향을 확인한다. 이를 위해 저자는 총 수출에서의 외국인 부가가치 비율과 경제성장 사이의 U 자형 가설 (N 형태의 패턴이 아닌)에 초점을 맞추고 있다. U 자형 가설은 합동 OLS 분석 뿐 아니라 고정효과, GMM 시스템 및 3 단계 최소 자승법 추정치를 사용하여 검증된다.

둘째, 부문별 수준에서의 노동 생산성에 대한 비선형 GVC 참여 작업을 조사하기 위해 본 연구는 무역 데이터 베이스 (TiVA)와 각각 일치하는 두개의 대형산업 데이터 베이스를 활용하고 9 개의 제조업 분야를 분석한다. 본 논문의 경험적 분석은 상위 중산층과 고소득층의 부문별 데이터만을 사용하며, 이를 위해 합동 OLS 분석, 고정효과 분석, GMM

시스템 추정치를 이용하여 총 수출 내 외국인 부가가치 비율과 노동생산성 사이의 U 자형 (N 형태 패턴이 아닌) 가설에 초점을 맞추고있다. 이 U 자형 가설은 일부 부문별 편차가 있는 대부분의 분야에서 확인되었다.

셋째, 서로 다른 혁신 시스템의 차이를 알아내기 위하여 본 연구는 산업 데이터베이스 (WIOD)와 무역 데이터베이스 (TiVA)와 일치된 데이터를 사용한다. 제조업 부문은 명시적 지식 기반 부문과 암묵적 지식기반 부문으로 구분된다. 고정 효과와 시스템 GMM 추정 결과는 명시적 지식기반 부문이 더 개방적이면서 한계적 효과가 더 작다는 것을 보여준다.

본 연구는 경제성장과 부문별 업그레이드를 위한 글로벌 가치사슬 (GVCs)의 참여 확대를 신중하게 추진해야 하며, 그 핵심은 개발 과정의 어느 시점에서 국내 부가가치를 높일 수 있다는 점을 시사한다. 특히 산업 정책 입안자들은 각 부문별 GVC 특성을 고려해야 한다.

**주요어 : GVC, 업그레이드, 경제성장, 비선형 관계, 노동 생산성, 산업 혁신 시스템**

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